THE SEA-MAN'S PRACTICE,

CONTAINING

A FUNDAMENTAL PROBLEM IN

NAVIGATION,

Experimentally verified;

NAMELY,

Touching the Compass of the *EARTH* and *SEA*, and the Quantity of a Degree in our *English* Measures.

Also, an exact Method or Form of keeping a Reckoning at SEA in any kind or manner of Sailing.

With certain *TABLES* and other *RULES* Useful in *Navigation*; As also in the *Plotting* and *Surveying* of *Places*. The *Latitude* of the Principal Places in *ENGLAND*. The finding of Currents at *SEA*, and what Allowance is to be given in respect of them.

THE TENTH EDITION.

By RICHARD NORWOOD, Reader of the *Mathematicks*.

LONDON,
Printed by *W. Godbid*, for *Benjamin Harlock*, and are to be sold at his Shop on *London* Bridge, near *Thames-Street*. 1672.

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LONDON,

Printed by W. Godbid for Benjamin Thurlock, and are to be sold in his shop on London Bridge, near Thames-Street.

To the Right Honourable

ROBERT

Earl of *WARWICK*,

Baron of *LEES*, &c.

Right Honourable,

ALthough the knowledge and Practice of the Art of Navigation be of late years grown to a far greater Perfection, than it can appear to have had in any former Age; and by that means, the World, and all the parts thereof, have been further discovered, yea, sailed round about: the Traffick and entercourse of several Nations, how remote soever, facilitated: knowledge in Divine and Humane things divulged: and (which, as I conceive, is of most importance, seeming as yet to be the principal scope of the Divine Providence in discovering of these Mysteries) the light of the glorious Gospel of Christ, being the mighty power of God unto salvation, is extended to those silly captives of Satan in *America*, by means of those many Plantations we have amongst them: which Plantations (even from their first breathing) have received no small furtherance from your Noble favour and bounty, as I know by my own experience in that where sometimes I was, and have understood no less by others in the rest.

Yet notwithstanding this notable growth and daily exercise of the Art of *Navigation*, it still remains imperfect in some points. For whereas the practice thereof doth especially consist in the knowledge of Latitudes, Courses, and Distances; the way of finding Distances at Sea; namely, by the *Log* and *Line*, is rather opinionative and conjectural, than certain, being grounded upon this supposition, that the Compass of the World in any great Circle is 21600 *Italian* Miles (as they call them) and that such an *Italian* Mile contains 1000 Paces, and every of those Paces 5 *English* Feet: and according to these measures they divide their *Log-line*, and keep their account of the Ships way at Sea.

Having therefore by an Experiment which I made a year since, found more nearly the Compass of the Earth, and the quantity of a *degr.* on the same in our known measures, and applyed it to use in *Navigation*, in this Treatise following: and further added some other such things as I conceived to be wanting in the Practice of that Art: I have presumed to present it to your Lordship, as well because by your knowledge in *Navigation*, and the experience you have had in your Honourable enterprizes at Sea, you are well able to judge of it: as also being confident that according to your Noble disposition you will favourably accept thereof, though otherwise of it self unworthily. The most high God ever Blessed and glorious, multiply unto your Honour all his Blessings in Christ Jesus.

Your Honours in all due Observance.

RICHARD NORWOOD.

To the READER.

THe Circle of the Earth and Sea (as the Circumference of every Circle) contains 360 *degr.* by which *degr.* the distances thereon are measured, so that the knowledge of the quantity of such a *deg.* in our known measures, is a fundamental Principle in *Cosmography* and *Navigation*, as upon which is grounded the reckoning of the Ships way, or distance run. For though a Mariner being in his Voyage on the vast Ocean, hath sometimes three things to certifie him where he is, and how to shape his Course to his desired Port, namely, his Latitude, Course and Distance; and sometimes a fourth, namely, some near conjecture of his Longitude by the Variation or otherwise; yet oftentimes (as in close weather) he hath nothing but his Course and distance; otherwhiles only his Latitude and Distances is his chief guide in falling with his intended Port. I know it is usual to allow near 7 Fathoms or 41 $\frac{2}{3}$ Feet to a Knot, and so many of those Knots as run out in half a Minute, so many Miles they account the Ships way to be in an hour. And if in half a *min.* she run 41 $\frac{2}{3}$ Feet, then in 60 *min.* or an hour, she runs 5000 Feet; and thus they account 5000 *English* Feet, or 1000 Paces to be a Mile, and 60 of those Miles to be a *degr.* such as the whole Circumference in any great Circle is 360. But how is this known to be true? If it be answered, that it is known to be so by Experience; then I would know further by what Experiment this was found to be so? Where, & by whom made? I press this so much the rather, because I am perswaded we have at this day as many excellent *Navigators* in this Kingdom, and as great Voyages performed, as from any other place in the World; and I should be glad to hear of the experimental resolution of this *Problem* by some of them, though it were but in running 8 or 10 *degr.* near the Meridian: for so I doubt not but that which I have here written thereof, would receive further confirmation, and better entertainment, than happily it will now, being so much different from the common opinion, and the Arts of *Navigation* and *Cosmography*, would be much more perfected in short time. For one Errour (as a fruitful Mother) is oftentimes the cause of more, and so the removing of one is the occasion of removing others, especially when they do mutually support one another: As we shall here shew how the Error in the projection and use of the common *Sea-Charts*, is supported by this Error of accounting only 300000 of our feet to a *degr.* and this in like sort upheld by that, so that they will stand or fall together. And surely that had fallen long since, being so manifestly convinced, if it had not been upheld by this. For the

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confuting of that, (I mean the common *Sea-Chart*) it was sufficient to know that the Earth and Sea make one Spherical body, but in disproving and rectifying this, it is necessary to know moreover what is the quantity of that Spherical body: and to that end, it was necessary to make a sensible application of our known Measures, to a determined part of the whole, that so the quantity of that determined part being known, and the proportion thereof to the whole, the quantity of the whole might also be discovered. And this I have endeavoured in the Experiment following, which If I have not handled so exactly in all points as some would desire: That requiring more time & charge, (than I could well bestow) yet I doubt not but it will be found that I have come very near the Truth. Some happily will censure me for being my self at the expence to make such an Experiment. But I was as frugal in it as I could, adding pains and industry to save expence; I came up in 10 or 11 days, and had other necessary occasions to lead me from the one place to the other, and did this as a thing falling opportunely in my way. But indeed (as in all other parts of Learning) so in the Mathematicks, especially in their application, or middle Mathematicks (as some call them) it is necessary with Speculation to joyn actual and experimental practices; the former being empty and uncertain without these. It is true, that the Mathematicks afford large Fields of delightful speculations, wherein a Man might walk far with much pleasure: But if from so many fair Flowers he bring home no Honey, or from such large Fields no sheaves: I mean, if he bring not those Speculations to some useful practices, neither himself nor others are like to receive much fruit by them. But this indeed cannot be effected without more labour and difficulty, yet sometimes it requires Mechanical and bodily exercises, which some esteem too mean and unworthy to stoop unto. But for mine own part, I acknowledge to have had my living and maintenance by the Mathematicks, and not by Speculation only, but rather by my practice therein; and therefore also I desire (what in me lies) to make them fruitful to my self and others; And to that end have spent in some Principal parts of the Mathematicks, near as much time and means in experimental Practices and Conclusions, as in the Speculation: Moreover, considering that this particular Experiment was propoſed above 30 years since by our Countreyman Mr. *Edward Wright*, to invite some to the tryal of it, as a thing which he would have done himself, if he had found such furtherance and opportunity as he desired, which it seems he did not, nor any other since that time. Rather than so noble and so necessary a *Problem* should longer rest unresolved, I took the opportunity offered, hoping it may be an occasion to whet on some others to do the like. This with some other things which I conceived to be wanting in the Practice of *Navigation*, I have handled in this ensuing Treatise, which I commend to your friendly acceptance, *Farewell*.

July *the first*, 1636.

THE

THE SEA-MANS Practice.

CHAP. I.

The common Opinion touching the Compass of the Earth, and quantity of a Degree of the same.

IT is a common received Opinion in *England*, (and the like is in other places) that allowing 5 of our *English* Feet to a Geometrical Pace, 1000 of those Paces make an *Italian* Mile, and 60 of those Miles in any great Circle upon the Spherical Surface of the Earth or Sea make a Degree; and thus it is supposed, that a Degree contains 60 Miles, or 60000 Paces, or 300000 of our *English* Feet, and by such Miles do Mariners in their Voyages by Sea keep their Reckonings: And because the whole Circumference of a Circle is 360 Degrees, therefore the compass of the Earth, according to this Opinion, should be 21600 such *Italian* Miles, or 21600000 Paces, or 108000000 of our *English* Feet. Whence this Opinion came, or upon what experiment it should be grounded, I cannot certainly say; It may seem to be taken, or rather mistaken from *Ptolomy*, who saith, there

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are 500 *Stadiums* in a Degree, the same was before affirmed by *Martinius Tyrius*, of whom *Ptolomy* speaking in the 11 Chap. of his first Book of *Geography*, hath these words, *Sed in hoc quoque recte sentit partem unum qualium est circulus maximus tricentorum sexaginta, quinginta in terra constituere Stadia, id enim confessis dimensionibus consonum existit.* Now a *Stadium* not only amongst the *Greeks*, but as appears by *Herodotus*, amongst all other Nations of *Asia* and in *Egypt*, did consist of 600 Feet, or 100 *Orgyas*, an *Orgya* containing 6 Feet or 4 Cubits, as our Fathom doth: the same also is testified by *Suidas*, and others: so that a *deg.* containing 500 *Stadiums*, and every *Stadium* 600 Feet, it follows that a *deg.* must contain 300000 Feet, exactly agreeing in number with the common received opinion in *England*, which therefore may seem to be hence derived, and would also receive much confirmation hereby (he being an Author of such approved credit) if it could be approved that our *English* Feet were exactly equal to the *Egyptian* or *Alexandrian* Foot, where *Ptolomy* wrote. Otherwise that being true, that so many of their Feet make a *deg.* it will follow, that if ours be greater, there be fewer of them contained in a *deg.* if lesser, (as undoubtedly they are) there must be more of them contained in a *deg.*

Philander in his Commentary upon the third Chap. of the third Book of *Vitruvius*, hath expressed the quantity of the ancient *Roman* foot, where (by a competetent allowance for the shrinking of the Paper being printed wet) it may probably be gathered that it was something longer than our *English* Foot. But the *Alexandrian* and *Egyptian* Foot was much greater, for according to *Heronechanicus*, 5 *Alexandrian* Feet were equal to 6 *Roman* Feet: seeing then the ancient *Roman* Foot was something greater than ours, the *Alexandrian* foot must needs be much greater than ours. So that whereas *Ptolomy* saith there are 500 *Stadiums* in a Degree, and as we have shewed a *Stadium* did consist of 600 Feet, these being *Egyptian* or *Alexandrian* Feet, as it is most probable, being the place where *Ptolomy* lived; there must be a far greater number of our Feet in a *Stadium*, and so in a Degree; whence it is evident, that there is no sufficient footing for this common opinion in the assertion of *Ptolomy*. Neither

Neither doth the Practice and Experience of Mariners in their Voyages at Sea prove it; for there is no reckoning or experiment at Sea set down by any (that I have seen) to confirm it. And though it be true, that in Sailing between two places that lie near to one and the same parallel, they ground their reckoning chiefly upon this supposition, that 300000 of our *English* Feet make a Degree, yet can they seldome or never by those reckonings discern the Errour, the rather for that they have been, and for the most part are still kept upon the Plain or Common *Sea-Chart*, which makes a Degree in any Parallel equal to a Degree in the Equinoctial, and so makes a Degree in any Parallel to contain 300000 Feet: And it is true, that in some Parallel a Degree doth contain only 300000 of our *English* Feet, namely, about that Parallel which is in Latitude 35 Degrees (as we shall further shew hereafter) near unto which have the principal of our Eastern and Western Voyages been made. And thus, though this Opinion of 300000 Feet in a Degree, and the Projection of the *Common-Chart* be both erronious: yet because the errour of the one doth something salve the other, they could not be so easily discerned by Experience only.

This Opinion of 300000 *English* Feet to a Degree, may seem also to be something confirmed by an Observation made by our Countrey-man Master *Edward Wright*, upon Mount *Edgecom* near *Plimouth*, of the Semidiameter of the Earth, which he hath set down in his Book, *Of the Correction of Errours in Navigation*, Chapter 15. where he finds the Semidiameter to be 18312621 of our *English* Feet, whence it may be gathered, that in a Degree of a great Circle of the Earth, there should not be full out 320000 of our Feet; but the way by him then used, though it was very fit for the end whereunto he there applies it; namely, to find the dipping or depression of the apparent Horizon beneath the true, according to the heighth of the Eye above the water, yet will it easily be granted to be no exact way for finding the Semidiameter, and consequently the Circumference of the Earth, or the Quantity of a Degree

on the same; and so he sayes there, that he used that way, because he wanted opportunity to put in practice a more exact way. Wherefore for the further satisfaction of my self and others in this point, and chiefly for the necessary use it hath in the Practice of *Navigation*, I have made the experiment following, that so the quantity of a Degree, and of the whole Compass of the Earth might at least-wise be nearly known in our *English* Measures.

CHAP. II.

An Experiment made for finding the quantity of a Degree, *and so the Circumference of the Earth and Sea in our known Measures.*

HAving occasion to be in the City of *York*, about the beginning of *June*, *Anno* 1635. I made there several Observations of the Meridian Altitude of the Sun, the last of which was made the 11 day of *June*, the Skie was every of those days something overcast at Noon, yet not so much but that an Observation might be made to near scantling: And because the last of those Observations is most fit for the present occasion, and that Day was as clear as any of the other, we will here especially make use of that, being as followeth.

Upon the 11 of *June* 1635. I made an Observation near the middle of the City of *York*, of the Meridian Altitude of the Sun, by an Arch of a *Sextans* of more than 5 Foot Semidiameter, and found the apparent Altitude of the Sun that Day at Noon to be 59 *deg.* 33 *min.*

I had also formerly upon the 11 Day of *June*, *Anno* 1633. observed in the City of *London*, near the Tower, the apparent Meridian Altitude of the Sun, and found the same to be 62 *deg.* 2 *min.*

And

And seeing the Suns Declination upon the 11 day of *June* 1635, and upon the 6th day of *June* 1633, was one and the same, without any sensible Difference; and because these Altitudes differ but little, we shall not need to make any alteration or allowance, in respect of Declination, Refraction, or Parallax: Wherefore substracting the lesser apparent Altitude; namely, 59 degr. 33 min. from the greater 62 degr. 1 min. there remains 2 degr. 28 min. which is the Difference of Latitude of these two Cities; namely, of *London* and *York*.

Also by the aforesaid Observation made in *York*, it appears, that the Latitude of that City, is 53 Degrees, 58 Minutes almost.

But to our purpose; Coming at that time from thence to *London*, I further found by Measure, that the Parallel of *York*, is from the Parallel of *London*, 9149 Chains; every Chain being 6 Poles, and every Pole $16\frac{1}{2}$ of our *English* Feet; that is, every Chain 99 Feet. (After what manner I found this to be so, we shall further express hereafter:) But thus, as I say, I found that *York* is more Northerly than *London*, by 9149 Chains: And before we have noted that these two places differ in Latitude 2 Degrees 28 Minutes: therefore it follows, that 2 Degrees 28 Minutes of the Meridian of the Earth and Sea, is equal to 9149 Chains. And if accordingly we would know how many of these Chains are contained in 1 Degree, we may find that by the Rule of Proportion, first reducing the Degrees into Minutes, and then say,

If the difference of Latitude	148 *m.*	7.82974
give such a number of Chains.	9149	3.96137
Then 1 Degree, that is	60	1.77815
gives of such Chains	3709	3.56916

and somewhat more, namely, 5 Feet, which reduced into Feet, make 367196; that is, 367200 Feet in a Degree, lacking 4 Feet, which here we regard not.

Thus then, according to this Experiment, it is evident, that one Degree of a great Circle measured on the Earth is near 367200 Feet, which in our Poles of $16\frac{1}{2}$ Feet, is 22254 Poles, and about one half, and these reduced into Furlongs, at 40 Poles to the Furlong, make 556 Furlongs and 14 Poles: and lastly, these reduced into our *English* Miles, of 8 Furlongs to a Mile, make 69 Miles, and 4 Furlongs 14 Poles, that is $69\frac{1}{2}$ Miles and 14 Poles in a Degree.

And hence, according to the most approved *Hypothesis* of the Sphericity of this Terrestrial Globe, we may find the Compass of it as followeth. But first, you may Note that we speak not here of the Compass of the Earth in any Parallel, or lesser Circle described upon any side hereof, that being various according to the different distance of those Circles from their Poles) but of the Compass taken in the middle or greatest thickness of the Globe; namely, in any great Circle, such as divide the whole Globe into two equal parts; of which kind are the Equinoctial and all Meridians, *&c.* this being properly the *Perimeter* or *Compass* of a *Spherical Body*.

Now seeing a Degree is the 360 part of the Circumference of a Circle (for any Circumference being divided actually or by supposition into 360 equal parts, those parts are called Degrees) if we can find how many Feet, Paces, Miles, or other known measures are contained in one of those Degrees, then shall we easily conclude how many of the same known measures are contained in the whole Circumference: But by the former Experiment we find, that in one *deg.* of a great Circle on the *Spherical Superficies* of the Earth there is contained 367200 Feet; therefore it is evident that 360 times 367200 Feet is the Compass of the whole; wherefore multiplying 367200 by 360, the Product is 132192000 Feet, which reduced into Poles is 8011636, and these reduced into Furlongs, are 200290 Furlongs 36 Poles: and lastly, these reduced into Miles, are 25036 *English* Miles, and somewhat more, for the Circuit of the Earth and Sea.

If further we desire the Diameter and Semidiameter of the Earth: Forasmuch as it is proved by *Archimedes*, that the proportion of the Circumference of a Circle is to the Diameter thereof, almost as 22 to 7: Therefore by the Rule of Proportion, as 22 to 7: so is the Circumference of the Earth, to the Diameter thereof: So that multiplying the Circumference of the Earth; namely, 132192000 Feet by 7, and Dividing the Product, namely, 925344000 by 22 the Quotient, namely, 42061⅑ is the Diameter of the Earth in Feet, the half whereof, namely, 21030545 Feet is the Semidiameter of the same, being 21 millions of Feet, and somewhat more: these reduced into *English* Miles, as before we did the Circumference, shew the Diameter of the Earth to be 7966 miles and somewhat more, and the Semidiameter 3983. And thus we have the Circumference, Diameter, and Semidiameter of the Earth, as also the Quantity of a Degree of the same Circumference in known measures of Feet, Furlongs, and Miles, *&c.* There are only two things here, which may seem doubtful; namely, the Experiment it self, and the *Hypothesis* of the Sphericity of this *Terrestrial Globe* consisting of the Earth and Sea; for these being admitted, the measures thence reduced as before, will necessarily follow.

Now touching the Experiment; I confess, that to have made it so exactly as were requisite, and in all Poinst so as I shall shew in the Chapter following, would have required much more time and expence than mine ability would reach unto; Yet having made Observation at *York*, as aforesaid, I measured (for the most part) the way from thence to *London*; and where I measured not, I paced; (wherein through Custom I usually come very near the truth) observing all the way as I came, with a Circumferentor all the prinipal Angles of Positions or Windings of the way, (with convenient allowance for other lesser Windings, Ascents and Descents,) and these I laid not down by a Protraction after the usual manner, but framed a Table much more exact and fit for this purpose, as we shall hereafter shew; so that I may affirm the Experiment to be near the truth.

Touching

Touching the *Hypotheſis*, that the Earth and Sea make one Spherical or round Body, it is generally agreed upon by all the principal Philoſophers, Aſtronomers, Geographers, Navigators, Antient and Modern; ſome reaſons demonſtrative for the confirmation thereof, may be theſe.

Firſt, the Eclipſes, eſpecially of the Moon, which are cauſed by the ſhadow of the Body of the Earth, being interpoſed between the Sun and the Moon; and foraſmuch as this ſhadow doth fall upon the Moon, always and upon every ſide Circular, and ſo appears to us, it is manifeſt by the Opticks, that the Earth from whence it proceeds is a Spherical Body.

Secondly, Likewiſe the Eclipſes of the Sun, which are cauſed by the interpoſition of the Moon between the Sun; and thoſe places where it appears Eclipſed; I ſay, could not be determined when, and in what place ſuch an Eclipſe ſhould appear, and where not, if the form of the Earth were not known; but ſeeing the places where ſuch Eclipſes happen, and where not, may be, and are uſually determined, and that upon this Ground; that the Surface of the Earth is Spherical, it is thence alſo ratified to be a truth.

Thirdly, the Sun, Moon, and Stars do riſe and ſet, and are upon the Meridian ſooner to thoſe that are reſident in the Eaſtern parts, than to others more Weſterly, and that in a proportion anſwerable to the roundneſs of the Earth, as the Planets and Stars are upon our Meridian at *London* ſooner by almoſt 4 hours, than they are to thoſe that Inhabit *Summer Iſlands*, and the confines of *Virginia* and *New England*: And ſo in *Eaſt India*, and other Eaſtern Regions, the Sun and Stars are ſooner upon their Meridian than upon ours; which is manifeſt to be ſo, as by other reaſons, ſo eſpecially by the Eclipſes of the Moon: for an Eclipſe of the Moon hath not in it ſelf any diverſity of time, being at one and the ſame inſtant without reſpect of places, yet becauſe in the Eaſtern parts the Day is begun, and it may be far ſpent before it begin in places far Weſterly, therefore ſuch an Eclipſe may appear to the Eaſtern Inhabitants towards the end of their Night, which to the Weſtern appears in the beginning

ginning or middle of the ſame Night with them, and ſo the difference will be more or leſs, according to the different diſtance of thoſe places in Longitude.

Fourthly, Furthermore we ſee, that going or Sailing to the Northwards, We have the Artick Pole and Southern Stars more elevated, and the Antartick Pole and Southern Stars more depreſſed, the Elevation Northerly increaſing equally, with the depreſſion Southerly, and either of them proportional to the Diſtances which we go: The like happeneth in going to the Southwards. Beſides the Oblique Aſcenſions, Deſcenſions, Occultations, Emerſions, and Amplitudes of Riſing and Setting of the Sun and Stars, in every ſeveral Latitude, agreeable to the *Hypotheſis* of the Earth's Sphericity. All which could not be ſo, if the Earth were of any other than of a Spherical form.

Fifthly, So if we ſtand upon the Sea-ſhore, and ſee a Ship far off under Sail, making towards the Land, at firſt wee ſee only the top-Sails or higheſt parts, and withall do manifeſtly behold the Convex Superficies of the Sea, as it were raiſed and interpoſing her ſelf between our ſight and the Hull, or lower parts of the Ship, till ſhe approacheth nearer, and this uniformly, every ways alike, and proportionably to the ſeveral diſtances; which doth evidently demonſtrate the Spherical roundneſs thereof.

Sixthly, And laſtly, (to add no more) the Navigations of theſe later times make it apparent, thoſe eſpecially that have been made round about the World, as thoſe two Voyages by our famous Country-men Sir *Frances Drake*, and Mr. *Thomas Candiſh*, both which ſeverally Sailing from our Coaſts to the *Weſt-Indies*, and paſſing the Streights of *Magellane*, continued their Courſe Weſterly, till they came into thoſe parts, which are from us to the Eaſtwards; namely, to the *Eaſt Indies*, and ſo Sailed ſtill Weſterly till they came to *Cape bon Eſperance*, and thence returned into *England*: Having Sailed about the whole Terreſtrial Globe, they found nothing by their obſervations or Reckonings diſſonant from the uniform *Sphericity* thereof in all its parts. That they came ſhort in the number of Dayes, one, or reckoned the time of their abſence leſs by one Day and a Night than they

which

which remained at home; this further confirms the thing in hand.

Yet whilst we speak here of the Roundness of the Earth and Sea, we intend it not so strictly as if it were a thing turned round without any inequality in its Superficies: But as a Bowl or Ball though it have some dust or small grains of Sand cleaving thereto, may still be said to be round: So, though the Land, Hills, and Mountains be somewhat raised above the Spherical Superficies of the Sea; and if there should be also some Valleys or Bottoms more depressed; Yet seeing the greatest of these inequalities have scarce any sensible proportion of the whole, we may well affirm the whole to be round.

The Relations made of the Prodigious height of the Mountains, as to be 60 or 70 Miles high, if it be understood of their perpendicular or direct height, are fabulous; the Mount *Atlas* Recorded by some of the Ancient, to reach up almost to the Moon, and to be as it were a Pillar for the Heavens to rest upon, being measured Geometrically by *Eratosthenes*, the perpendicular or upright height from the top thereof to the Valleys beneath, was found not to exceed 10 *Stadiums*, which of our *English* measures is little more than a Mile and a quarter, a *Stadium* not much differing from our Furlong; and the like might be shewed of others.

But if we admit the highest Mountain to rise perpendicularly above the Spherical Superficies of the Sea 2 Miles; yet seeing the Diameter or whole thickness of the Earth, is, as we have before shewed, 7966 Miles, this exorbitancy or difference of 2 Miles is of small moment; yea, if there were any Mountain 8 Miles in height upright, yet this compared with the whole thickness of the Earth, is little more than one thousand part thereof; therefore we may conclude, that this *Terrestrial Globe*, consisting of the Earth and Sea, is *Spherical*. We come in the next place to shew by what way of Measuring we found the Parallel of *York*, to be distant from the Parallel of *London*, 9149 Chains. And so how the distance of the Parallels of two Places may be exactly measured.

CHAP. III.

A most exact way for finding the quantity of the Diameter and Circumference of the Earth and Sea, and of a Degree on the same.

I Do the more fully set down the way of making this Experiment, that so I may give occasion to any who are so Nobly minded for a Publick good, as to be at that Charge to make a further and more exact tryal thereof. Now then, the best and perfectest way is, to observe so exactly as may be the Summer *Solstitial Altitudes* of the Sun at two places, so far distant asunder, and lying so near North and South each from other, with so direct and fair a way betwixt them, as conveniently may be chosen: Suppose for Example, *Christ-Church* and *Berwick*, or some other place in the furthest parts of *Scotland*, for the further these two places are each from other, the more perfectly may this business be performed. Then measure as truly as is possible, and set down in a Book, all the way between these two places, with all the Windings, Ascents and Descents that are therein, whereby with the help of the ensuing Table, you may easily and exactly find how much the one place is more Southerly than the other. For this purpose the *Plain Table* is not the fittest Instrument, but rather a *Theodolite* or *Peradar*, or some other of that kind, observing diligently the Variation of the Needle. The Chain may be 6 Poles long, or rather 100 Feet, and the Table fitted accordingly (but the Table following is for Poles) if it should be much longer, it would be too heavy.

The High ways are commonly crooked, yet because of sundry obstacles and impediments which are incident out of the way, and because a Man cannot certainly at first direct himself the neerest and best way to the place intended, it would be expedient to measure the Distance as aforesaid, First, in the High-ways leading,

leading from the one to the other, and then in the neareſt and beſt way that could be choſen between them; and ſo if any notable Errour happen in the one, it may be diſcovered and amended in the other. The form which I obſerved in ſetting down the meaſures and Angles, was according to this Example.

Deg.	*Diſtance.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
S E 31					
S E 20					I
S E 13					
S E 13					
S W 02					
S E 05					

It is to be underſtood, that the Table here following was before Calculated to ſerve inſtead of a *Protractor*, for a *Circumferentor*, or other Graduated Inſtrument, and for a Chain of 3 Poles, which for the moſt part I uſe; yet it may very well be applyed to a Chain of 6 Poles, (as in this buſineſs it was) reckoning every Chain to be two, *&c.* And thus for every ten Chains of ſix Poles to a Chain, I make two Strokes, ſignifying two Changes or 20 Chains, and if there be any odd Chains, for thoſe I ſet a Figure in another Line next below, and if moreover any odd Poles, whether one or two, for thoſe I ſet another in a third Line below.

Thus the laſt entrance before-going, being *S E* 05 *degr.* 5 2 ſignifies that the Line upon which I went, was

from

from the South part of the Meridian of 5 *degr.* the 9 Strokes signifie 9 Chaines, or 90 Chains; the Figure 5 signifyeth five Chains, and the Figure 2 two Poles. So that it is to be read thus, South-Easterly 5 Degrees, 9 Chaines, 5 Chains, and 2 Poles; and the like is to be understood of the rest. But for the most part having liberty of Ground, I send the measure of every Line, either with a whole number of Chaines, or at least of Chains.

And thus proceeding all Day, towards the Evening, or when else I have a time convenient, I reduce all these Distances, upon what Lines or Angles, soever they be, to Distances of North or South, East or West, as here appears.

Deg.	*Distance.*	*North.*	*South.*	*East.*	*West.*
			2571	1543	
S E			1819	1026	
S E	29		1692	618	
			0169	002	
S E	13		2823	675	
			754	404	
S E	23		1699		052
			3690	235	
S W	02		0149	013	
S E	05		0020	002	
Chains.		57.12	162.86	46.78	952
		0		52	
Poles.		57.12	162.86	45.26	

We will explain the last, and so the rest may easily be understood: *S E* 5 *deg.* 9 - 5. 2. Here because I have *S. E.* the numbers taken out of the Table must be put into the Columns intituled *South* and *East*. Then the Table under 5 *deg.* I look for

for 9 Changes, and find against it 2690, and in the adjacent Column under the Complement thereof 235, and because S E 5 *degr.* is less than 45 *degr.* that is, nearer to the South than to the East, I put in the Column entituled South 2690, and in that entituled East 235, then again in the same Tabular Column under 9 *degr.* I find against 5 Chains, (cutting off a Figure, because 5 Chains is but the tenth part of 9 Changes) 149 to be put in the South Column, and 13 for the East Column.

Lastly, against 2 Poles I find for the South Column 20, and for the East 2, and the like is to be understood of all the rest.

Now supposing this last to be a Place, whose Distance and Situation from the first is required, I sum up the Columns severally, and of the North and South Columns Substract the lesser from the greater, and so of the East and West Columns, and so it will appear how much North or South, and how much East or West the last place is from the first.

As in this Example, we find the last place to be to the Southwards of the first 1628 Poles, for the last Figure may be cut off, being used in the Table, only for the more exactness, or may be made a Fraction, and so it is 1628$\frac{6}{10}$ Poles; Likewise, the last place is to the Eastwards of the first 452$\frac{1}{10}$ Poles, and thus I proceed all the way.

Now touching the Angles of Ascent and Descent of Hills and Valleys, to have observed them exactly, would have required more time and charge than I could of my self bestow; yet I made allowance for such of them as were of most moment; He that would observe them all, may either make 2 or 3 Columns more, or keep an account of them apart by themselves. But if he intend no further use of them, but to find the neareſt Distance, he need not set them down, but make allowance for them on the Ground, keeping his Distances intire without Fractions.

As, admit I observe the Ascent from a Valley to the brow of a Hill to be 14 *degr.* above the Level or Horizontal Line, and that measuring, I find the Distance to be 30 Poles; I turn to the Table, and under 14 *degr.* and against 10 Chains, I find 2911, and 726, shewing that the Level or Horizontal Distance from

my

my Station, to that Brow, is only $29\frac{11}{100}$ Poles, and that the height of that Brow above the Level Line, is $7\frac{86}{100}$ Poles: But finding thus that the *Hypothenusal* being 30, the Base or Level Line is but $29\frac{11}{100}$, that is less by $\frac{89}{100}$, because I would avoid this Fraction, I add to the end of the foresaid measure of 30 Poles upon a Level Line, $\frac{89}{100}$ of a Pole, and then I may account my self distant from the place in the Valley where I made Observation, 30 Poles in a Level or Horizontal Line, and so set down the Distance without a Fraction: the like is to be understood of all other Ascents and Descents.

Here followeth the Table.

	1. d.	89 d.	2. d.	88 d.	3. d.	87 d.	4 d.	86 d.	5 d.	85 d.
1	300	5	300	10	300	15	299	21	299	26
2	600	10	600	21	600	31	599	42	598	52
3	900	15	900	31	899	46	898	63	896	79
4	1200	20	1200	42	1198	62	1198	84	1195	105
5	1500	26	1500	53	1495	78	1497	105	1494	131
6	1800	31	1799	64	1798	93	1796	126	1794	157
7	2100	37	2099	74	2097	110	2095	147	2093	183
8	2400	42	2398	84	2397	124	2394	168	2391	209
9	2700	47	2698	95	2696	140	2694	189	2690	235
10	3000	52	2998	105	2996	157	2993	210	2989	262
1	10	00	10	0	10	0	10	1	10	1
2	20	00	20	1	20	1	20	1	20	2

	6. d.	84 d.	7. d.	83 d.	8 d.	82 d	9 d.	81 d.	10 d.	80 d.
1	298	31	298	37	297	42	296	47	295	52
2	597	62	596	74	594	84	592	94	590	104
3	895	94	894	111	891	125	889	140	887	156
4	1193	126	1192	146	1188	167	1185	187	1182	208
5	1492	157	1489	183	1485	209	1481	234	1477	260
6	1790	188	1787	220	1782	251	1777	281	1772	312
7	2089	220	2085	257	2080	292	2074	328	2069	365
8	2386	251	2383	292	2377	334	2371	375	2364	417
9	2686	283	2680	329	2674	376	2667	422	2659	469
10	298	214	2978	366	2971	418	2963	469	2954	521
1	10	1	10	1	10	2	10	1	10	1
2	20	2	20	2	20	1	20	3	20	3

Here followeth the Table.

	11 d.	79 d.	12 d.	78 d.	13 d.	77 d.	14 d.	76 d.	15 d.	75 d.
1	295	57	293	67	291	67	290	73	299	78
2	590	114	586	124	584	134	582	146	580	156
3	883	172	881	188	876	203	873	219	870	233
4	1178	229	1174	250	1169	270	1164	290	1160	310
5	1473	286	1467	312	1461	337	1455	363	1449	388
6	1768	343	1760	374	1754	404	1746	436	1739	466
7	2060	401	2055	436	2047	472	2038	508	2030	543
8	2355	458	2348	500	2339	540	2329	580	2320	621
9	2650	515	2641	562	2631	608	2620	653	2610	699
10	2945	572	2934	624	2929	675	2911	726	2898	776
1	10	2	10	2	10	2	10	2	10	3
2	20	4	19	4	19	4	19	4	19	5

	16 d.	74 d.	17 d.	73 d.	18 d.	72 d.	19 d.	71 d.	20 d.	70 d.
1	2880	83	2887	88	2885	93	2884	98	2882	203
2	576	166	574	177	570	186	568	196	564	206
3	865	250	861	264	855	279	851	294	846	308
4	1153	332	1148	352	1140	371	1135	391	1128	411
5	1442	413	1434	438	1426	463	1418	488	1410	513
6	1730	496	1721	526	1711	555	1702	586	1691	616
7	2019	580	2008	615	1997	649	1986	684	1973	719
8	2307	663	2296	703	2282	743	2270	782	2255	821
9	2596	746	2583	791	2567	836	2552	880	2537	924
10	2884	827	2869	877	2853	927	2836	977	2819	1026
1	10	3	10	3	10	3	10	3	10	3
2	20	7	19	6	19	6	19	6	19	6

	21 d.	69 d.	22 d.	68 d.	23 d.	67 d.	24 d.	66 d.	25 d.	65 d.
1	1280	107	1276	112	1276	117	1274	122	1272	127
2	560	215	556	224	552	234	548	244	544	254
3	840	323	834	337	828	351	822	366	816	381
4	1120	429	1112	449	1104	468	1096	488	1088	508
5	1400	537	1391	562	1380	586	1370	610	1360	634
6	1680	645	1669	674	1656	703	1644	732	1632	761
7	1960	752	1947	786	1932	820	1918	854	1904	888
8	2240	860	2225	899	2209	937	2192	976	2175	1015
9	2521	968	2504	1011	2485	1054	2466	1098	2447	1142
10	2801	1075	2782	1124	2761	1172	2740	1220	2719	1268
1	9	4	9	4	9	4	9	4	9	4
2	18	7	18	8	18	8	18	8	18	8

	26 d.	64 d.	27 d.	63 d.	28 d.	62 d.	29 d.	61 d.	30 d.	60 d.
1	270	131	267	136	265	141	262	145	260	150
2	540	263	534	272	530	282	524	290	520	300
3	810	394	801	408	795	423	786	435	780	450
4	1079	525	1068	544	1060	564	1048	581	1040	600
5	1348	657	1336	681	1324	704	1312	727	1299	750
6	1618	788	1603	817	1589	845	1574	872	1559	900
7	1888	919	1870	953	1855	986	1836	1017	1819	1050
8	2157	1050	2138	1089	2120	1127	2098	1162	2079	1200
9	2427	1182	2405	1225	2384	1267	2361	1308	2339	1350
10	2696	1315	2673	1362	2649	1408	2624	4454	2598	1500
1	9	4	9	5	9	5	9	5	9	5
2	18	8	18	10	18	10	18	10	18	10

	31 d.	50 d.	32 d.	58 d.	33 d.	57 d.	34 d.	56 d.	35 d.	55 d.
1	257	154	254	159	252	163	249	168	246	172
2	514	309	508	318	504	326	498	336	492	344
3	773	463	763	477	755	489	747	504	738	516
4	1028	617	1017	636	1007	653	995	671	983	686
5	1285	772	1272	795	1258	817	1243	838	1228	860
6	1542	927	1526	954	1510	980	1492	1006	1474	1032
7	1809	1081	1780	1113	1762	1143	1741	1174	1720	1204
8	1057	1235	2034	1272	2013	1307	1990	1342	1966	1377
9	2314	1390	2288	1431	2265	1470	2238	1510	2212	1549
10	2571	1545	2544	1590	2516	1634	2487	1677	2467	1721
1	9	5	8	5	8	5	8	6	8	6
2	18	10	16	10	16	10	16	12	16	12

	36 d.	54 d.	37 d.	5 3 d.	38 d.	52 d.	39 d.	51 d.	40 d.	50 d.
1	243	176	240	180	236	185	233	189	230	193
2	486	352	480	360	472	370	466	378	460	386
3	729	528	720	541	709	555	699	567	690	578
4	971	705	960	721	945	739	932	756	920	771
5	1213	881	1198	902	1182	923	1165	944	1149	964
6	1456	1057	1438	1082	1418	1108	1398	1133	1379	1157
7	1699	1234	1678	1262	1654	1293	1631	1322	1609	1350
8	1942	1410	1918	1443	1890	1479	1865	1511	1839	1543
9	2185	1586	2157	1624	2126	1663	2094	1700	2059	1735
10	2427	1763	2396	1805	2364	1847	2331	1888	2298	1928
1	8	6	8	6	8	6	8	6	8	16
2	16	12	16	12	16	12	16	12	16	12

	41 d.	49 d.	42 d.	48 d.	43 d.	47 d.	44 d.	46 d.	45 d.	45 d.
1	226	197	223	201	219	205	216	208	212	212
2	452	394	446	402	438	410	432	416	424	424
3	678	591	669	603	658	614	648	625	636	636
4	905	788	892	803	878	819	864	833	849	849
5	1132	984	1114	1003	1097	1023	1079	1042	1061	1061
6	1358	1181	1337	1204	1316	1228	1295	1250	1273	1273
7	1584	1378	1560	1406	1535	1433	1511	1458	1485	1485
8	1810	1575	1783	1607	1754	1638	1727	1666	1697	1697
9	2036	1772	2006	1807	1974	1842	1943	1874	1910	1910
10	2236	1968	2229	2007	2194	2046	2158	2084	2122	2122
1	8	7	7	7	7	7	7	7	7	7
2	16	14	14	14	14	14	14	14	14	14

The Structure of this Table is from this Ground:

As *Radius* is in Proportion to the Distance of two places measured in their Rumb: So is the Sine of the Complement of that Rumb, to the Difference in Latitude of these two places.

And so is the Sine of that Rumb, to the Distance of the Meridians of those two Places. As, admit I measure South-Easterly 20 *deg.* 300 Poles, here then the Rumb upon which I measure, making with the Meridian an Angle of 20 *deg.* I say,

As *Radius* is in Proportion	
to the Distance measured 300 Poles;	2.47712
So is Sine Complement the Rumb, S E 20 *deg.*	9.97299
to the Difference of Latitude $281\frac{21}{100}$ *ferè.*	2.45011

Whereby it appears, that the Distance of the Parallels of these two places is $281\frac{21}{100}$ Poles; or that the place whereto I measure, is more Southerly than the place from which I measured, by $281\frac{21}{100}$ Poles. Now for the Distance of their Meridians, say,

As *Radius* is in Proportion	
to the distance measured 300 Poles;	2.47712
So is the Sine of the Rumb S E 20 *degr.*	9.53405
to their Distance in Longitude $102\frac{62}{100}$	2.01117

Ch	*Poles.*
1	28.19
2	56.38
3	84.57
4	112.76
5	140.95
6	169.14
7	197.33
8	225.52
9	253.71
10	281.92

And thus I find the place whereto I measured is more Easterly than the place from which I measured by $102\frac{62}{100}$ Poles, and somewhat more. And in like sort may be found all the other numbers expressed in this Table, but having thus found for every *degr.* to 45 *degr.* two numbers, the rest may be deduced from these, as in this Example: 300 Poles at three Poles to the Chain, is an 100 Chains or 10 Changes, finding that in 10 Changes upon this *degr.* the difference Southerly is $281\frac{2}{10}$ Poles, it must for 5 Changes, which is just half so much, be almost 141; and for one Change, which

which is a tenth part $28\frac{4}{10}$ *ferè*, and so for two Changes twice so much, that is $56\frac{8}{10}$, for three Changes thrice so much, that is, the sum of the two former, namely, $84\frac{12}{10}$, and so by Addition only you may find the rest, as in this Table, which I shall need to prosecute no further. And thus you may take it to the hundredth or thousand parts of a Pole; but this for ordinary occasions, for which it was at first intended, may suffice.

According to this Example, it will be easie to frame the like Table for a Chain of any other size, or for any other Measure which you use.

It may be objected, That howsoever this Rule holds true in plain Triangles, yet the Triangles here used are neither Plain nor Spherical; for a Plain Triangle is made of three right Lines, and a Spherical of three Arches of great Circles; But in this the three sides are of three several kinds, namely, one side is an Arch of the Meridian, and so of a great Circle; another an Arch of a Parallel, and so of a lesser Circle, the third side or *Hypothenusal* being the Rumb, is no Arch of a Circle, but a Segment of an Helispherical Line.

But I answer, That notwithstanding this may be speculatively conceived, and so demonstrated to be no Plain Triangle; yet in so small Distances as these which here we use, there can be no sensible nor scarce any numerable difference. Yea, the Distance between two Parallels by the Rumb and Distance given (being the thing here chiefly aimed at) is very exactly founded by this Rule, as before we have shewed, and as is more fully demonstrated by Mr. *Wright*, in the 12th Chapter of his Book, *Of the Correction of Errours in Navigation*: Whence we may conclude, that the parts of the Meridian collected by this Table according to the Rumbs and Distances, as we have before shewed, do give the true measure of the Segment of that Meridian intercepted, between the Parallels of the two places proposed.

CHAP. IV.

Of the difference of Longitude, Position, and Distance of York *and* London: *And how the Maps of* England *may by this Experiment be reformed, especially in the Latitude of Places.*

WE come next to speak of the Easterly and Westerly Distances gathered, as before is shewed by these Tables, and to find thereby the difference of Longitude; and of this we will give an Example in the foresaid Experiment; whereby we find that the Distance in Longitude, or the East and West Distance between *York* and *London* is near 14000 Poles, *London* being so much more Easterly than *York*. And before we have found that in a *degr.* of the Meridian, and consequently in a *degr.* of the Equinoctial, there is near $3709\frac{1}{10}$ Chains, at 6 Poles to the Chain, and this 14000 Poles converted into such Chains, is $2333\frac{1}{3}$.

Which $2333\frac{1}{3}$ Chains (for finding the difference of Longitude) are not to be reckoned in the Parallel of *York*, that being too much Northerly; neither in the Parallel of *London*, being too much Southerly, but in a middle Parallel between both; namely, about the Latitude of 52 *degr.* 45 *min.* Now to find what difference of Longitude is answerable to this $2333\frac{1}{3}$ Chains in the Parallel of 52 *degr.* 45 *min.* Lay,

As *Radius* is in Proportion	
to Sine Complement the Latit. *sc.* 52 *deg.* 45 *min.*	9.78197
So is the measure of a *deg.* in the Equinoctial $3709\frac{1}{10}$	3.56927
to the measure of a *degr.* in that Parallel $2245\frac{1}{10}$	3.35124

And thus we find that in the Parallel, whose Latitude is 52 *degr.* 45 *min.* there are 2245 $\frac{1}{19}$ Chains answering to a *degr.* whereby it appears that the difference of Longitude between *York* and *London*, is more than one *degr.* and to find how much more, say again by the Rule of Proportion.

As the measure of 2 *degr.* 2245 $\frac{1}{19}$	*Co. ar.*	6.648736
is to a *degr.* in *Seconds*, 3600		3.556302
So is the measure given, 2333 $\frac{1}{3}$		3.367977
to the number of *Seconds*, 3741		3.572303

Which reduced, is 1 *degr.* 2 *min.* 21 *seconds*; and thus we find that *London* doth differ in Longitude from *York*, 1 *degr.* 2 *min.* 21 *seconds*, being so much more Easterly.

Thus having the difference of Latitude, as also the difference of Longitude between these two places, we may (according to the Second Problem of Sailing by *Mercators Chart*) find the Rumb from *London* to *York* to be 14 *degr.* 20 *min.* from the North to the Westwards; that is, North and by West 3 *degr.* 5 *min.* Westerly; and the distance in that Rumb 9442 Chains. But their distance in the High-way, by reason of the crookedness and un-evenness of it, was more by about an eighth part.

And the like might be done for other intermediate Places between these, but affecting brevity, we pass that over, as not much pertinent to our present purpose; only expressing the Latitudes of some of the principal of them, as followeth.

	Latitudes.		
As the Latitude of *York*, we find to be	53 *deg.*	58	*min.*
Doncaster	53 *deg.*	32	*min.*
Newark upon *Trent*	53 *deg.*	5	*min.*
Grantham	52 *deg.*	54	*min.*
Stamford	52 *deg.*	38	*min.*
Huntington	52 *deg.*	19	*min.*
Royston	52 *deg.*	3	*min.*
Ware	51 *deg.*	48	*min.*
London	51 *deg.*	30	*min.*

We

We further noted in this Experiment, that howsoever the number of Miles between *Ware* and *London*, are almost the same by Estimation that they are by Measure; yet all the way besides from *York* to *Ware*, a measured Mile consisting of 320 Poles, is but three quarters of a Mile, as the Miles lie by Estimation or common account; so that every where (for the most part) three Miles by estimation make 4 measured Miles: and a *min.* or the 60th part of a *deg.* is almost in the middle between them both: So that look how much a measured Mile is less than a *min.* so much, or somewhat more is a Mile by Estimation greater than a *min.* for as there is contained in a *degr.* of measured Miles $69\frac{1}{2}$ and somewhat more, as we have before shewed; so of our common estimated Miles, there are contained about $51\frac{2}{3}$ in a *degr.*

Upon these Grounds the whole Maps of this Kingdom might be much rectifyed, especially in the Latitude of Places, for though we cannot hence determine certainly the Latitudes of any other places besides those which were in the way, or at least in sight as we came up (the Principal of which we have before noted.) Yet we may nearly conjecture the Latitudes of most parts of *England*, by their Distances and Positions from these; but these things being besides our scope and purpose in this place, we shall only compare the Latitude of some principal Places, probably gathered from this Experiment, with the Latitudes of the same places, as they are set down by Mr. *Speed* in his *Geographical* Descriptions of *England:* that such as please to examine both in any particulars, may know to which they may more safely lean.

Canterbury,

	Latitude by this Exper.		Latitude by Mr. Sp. Map.		Latitude by this Experi		Latitude by Mr. Sp. Map.	
	D.	M.	D.	M.	D.	M.	D.	M.
Canterbury	51	17	51	29	*Northampton*	52	14	52	36
Chichester	50	48	50	51	*Huntington*	52	16	52	44
Guilford	51	12	51	22	*Stamford*	52	38	53	04
Winchester	51	03	51	11	*Leicester*	53	40	53	06
Dorchester	50	40	50	44	*Lincoln*	53	14	53	50
Exceter	50	43	50	48	*Newark* up-				
Wells	51	12	51	22	on *Trent*	53	05	53	28
Salisbury	51	04	51	12	*Nottingham*	54	02	53	22
Redding	51	28	51	42	*Derby*	52	58	53	30
London	51	30	51	45	*Stafford*	52	52	53	22
Colchester	51	58	51	16	*Shrewsbury*	52	47	53	16
Ipswich	52	08	52	30	*Chester*	53	16	53	32
Norwich	52	42	53	10	*Lancaster*	54	10	54	52
Cambridge	52	12	52	32	*York*	53	58	54	44
Hertford	51	49	51	06	*Richmond* in				
Bedford	52	08	52	30	*York-shire*	54	28	55	18
Buckingham	52	00	52	26	*Kingston* up-				
Royston	52	04	52	24	on *Hull*	53	48	54	29
Oxford	51	46	52	02	*Doncaster*	53	32	54	12
Gloceſter	51	53	52	12	*Durham*	54	50	55	45
Hereford	52	07	52	27	*Carlile*	55	00	55	56
Worceſter	52	14	52	36	*Newcaſtle*	55	03	56	01
Warwick	52	20	52	45	*Barwick*	55	54	57	03

The Latitudes of these places in the first Column expressed, are such as are probably gathered from this Experiment. But in the second Column there is set down the Latitudes of the same places, as they are expressed by Mr. *John Speed* in his Map of *England*, set forth in his Book, Entituled, *The Theatre of the Empire of great Britain*; and lest there should be any mistake in his Map, I have conferred these Latitudes thence gathered, with the Latitudes of the same Places, set down by him in words at large, in his Descriptions of each several County, and find them nearly to agree, except in the Latitude of *Barwick*, which in his Map he makes to be 57 *degr.* 3 *min.* But in his Historical Descriptions of *Northumberland*, he relates it to be 55 *degr.* 48 *min.* which last is much nearer the truth, but seems not to be his meaning; because then he should make it more Southerly than *Newcastle*, yea, more Southerly than he doth *Carlile*, which by his Map, and also by his words in his relation of *Cumberland*, is in the Latitude of 55 *deg.* 56 *min.* whereas *Barwick* is above 50 Miles more Northerly.

By these you may nearly conjecture the Latitudes of other parts of *England*, lying in or near the same Parallel with any of them: And hence also it appears, that the difference of Latitude between *Barwick*, and the South Coast of *England* near *Christ-Church*, is little more than 5 *degr.* not 6 *degr.* and more, as some of our Maps make it. But these things we must leave, that we may proceed to that which is principally intended, only we will first touch a little upon the Use of the fore-going Table, in Plotting and Surveying of Land.

CHAP.

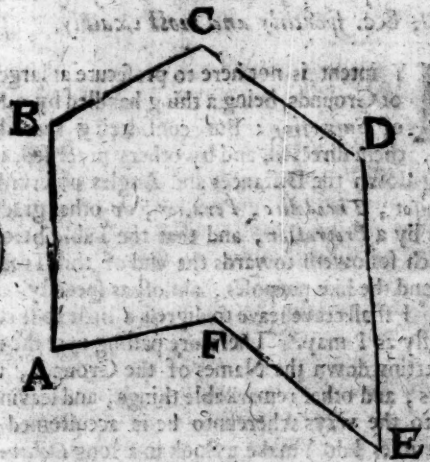
CHAP. V.

To Delineate the Plot of any Forrest, Park, Common, or other pieces of Ground: as also of Rivers, Harbours, &c. speedily and most exactly.

MY intent is not here to prosecute at large the Plotting of Grounds, being a thing handled by others, treating of *Surveying*: But considering that the wayes by them directed, and by others practised, in delineating or laying down the Distances and Angles observed by the *Circumferentor*, *Theodolite*, *Peractor*, or other graduated Instrument, is by a *Protractor*, and that the Table before going, or that which followeth towards the end of this Treatise, serveth for that and the like purposes, almost as speedily, and far more exactly; I shall crave leave to digress a little to shew this Use of it as briefly as I may. Therefore passing over the method to be used in setting down the Names of the Grounds, the Tenants, Borderers, and other remarkable things, and leaving every man in these to the ways whereunto he is accustomed; You may (as sometimes I do) make a Book in a long *Octavo*, and upon the left side thereof set down such things, as these before mentioned, reserving every right side, and dividing them by Ruled Lines into 6 Columns, as hereafter following appeareth.

And having taken and set down your Notes in the Field on the left sides or Pages of your Book, you may in the Eveting or next morning before you go out, or when else your occasions will permit, set down in the first Columns on the right side, how many *degr.* the Lines upon which you have Traversed, are distant from the North or South part of the Meridian towards the East or West, and in the second Columns the quantity of the same Lines, in Changes, Chains, and single Poles, and parts of Poles.

As in this Figure, suppose the Line from *A* to *B* to be directly East, 7 Changes, that is, 7 times 30 Poles, or 210 Poles, From *B* to *C* to the Eastwards of the South 35 *degr.* 8 Changes, and 1 Chain, from *C* to *D*, to the Westwards of the South 32 *degr.* 5 Changes, and 4 Chains, from *D* to *E* to the Westwards



of the South 80 *degr.* 10 Changes, from *E* to *F*, to the Eastwards of the North 35 *degr.* 6 Changes, 3 Chains, and two thirds of a Pole. And lastly, from *F* to *A*, the place where I first began, to the Westwards of the North 9 *degr.* 5 Changes, 3 Chains, 2⅔ Poles: All these I express in the first and second Columns on the right side, as hereafter following appeareth.

Which done, I take the Table, and find there the Northing and Southing, Easting or Westing answering to these *degr.* and Distances, and set them down accordingly. As for the first being East 7 Changes, I set down in the East Column 210 Poles with

with a Cypher behind it. For the second being *S E* 35 *degr.* I find in the Table for 5 Changes 1228, to be set in the South Column; and 860 for the East Column, also upon the same *degr.* for 1 Chain 25 for the South Column, and 17 for the East Column; and so I proceed with all the rest, untill I have finished.

Deg.	*Distance.*	*North.*	*South.*	*East.*	*West.*
East.	1			2100	
S E	35		1228	0869	
	2		0025	0017	
S W	32		1272		0795
	4		0102		0064
S W	80		0521		2954
	6				
N E	35	1474		1032	
	2	0074		0052	
	3	0005		0004	
N W	89	1481		0134	
	3	0089		0014	
	2 1/2	0025		0004	
		3148	3148	4065	4065

And being thus returned to my first Station, I sum up severally these 4 Columns of North, South, East and West; and finding that the sum of the North Column is equal to that of the South, and the sum of the East is equal to that of the West, I conclude the whole Work to be truly performed, whereas if there had been any difference, it had shewed an Errour, and if the difference had been great, it had been necessary to examine the Work again, and so correct it.

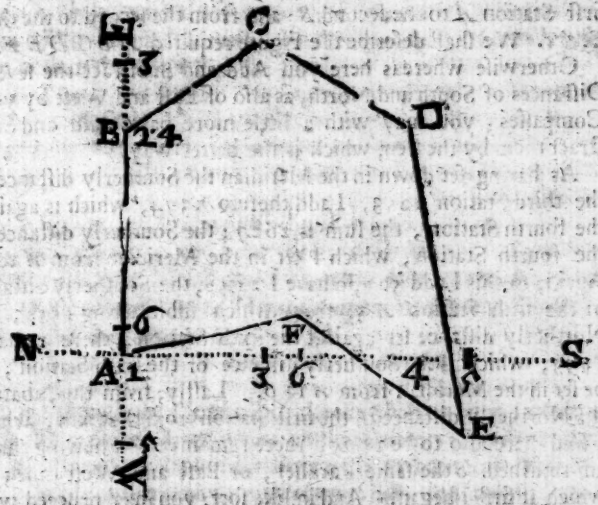
It is usual to add together all the Angles, and also to multiply two right Angles, or 180 *degr.* by the number of Angles lacking two; and if the Sum of the Angles added together, be equal to this Product, the Work is thought to be true: as here, if we add the Inclinations and Reclinations of these Lines in this Figure, the Sum is 720 *degr.* or 8 right Angles; and if we multiply two right Angles by 4, (because here are 6 Angles) the Product is also 8 right Angles. But the other by the Sums of the Columns, is a most absolute way for examining the truth of your Work, and to be preferred before any other that I know.

It may seem very laborious to set down every Station in this manner, but one that is a little exercised in it may, as I take it (for I never observed the time exactly) set down 40 or 50 Stations in this manner, within the space of an Hour, or thereabouts: But I should advise that it be done by two Men, having each a Table for that purpose to avoid all mistakes.

If your Instrument give not the Angle with the Meridian expressly, yet it may easily be gathered thence, or else you may divide a Circle as your Instrument is divided, and number the *degr.* as they are there numbred; which done, number them also from the N. and S. part of the Meridian towards the E. and W. so shall you easily know the Angle of any *degr.* with the Merid.

Now to proceed, these measures may be set down in a Plot several ways. As first, considering which way the Ground lies, I take a Point for my first Station, so as the whole may fall conveniently within the Plot, which let be the Point *A*, by which Point I draw a Meridian and Parallel, namely two right Lines intersecting one another at right Angles: whereof let *N S* be the Meridian running North and South, and *E W* the Parallel running East and West; this done, I look to the North and South Columns, and the first in the South Column, and against the third Station, I find 1253, that is, $125\frac{3}{10}$ Poles, this I set in the Meridian from *A* to the Southwards, and mark the Point with the Figure 3; then in the South Column against the fourth Station, I find 1374, which I set in the Meridian from 3 to 4: also against the first Station I find 521, which I set in the Meridian.

dian from 4 to 5. Then against the Sixth Station, I find in the North Column 1553, which I set in the Meridian from 5 to 6: also against the Seventh Station, which is the same with the First, I find 1595, which I set in the Meridian from 6, and it falls upon *A*, which is the first Station: and thus have I done with the South and North Columns.



In like sort I expres the measures in the East and West Columns in the Parallel *E W*. As finding first in the East Column 2100, I set it down from *A* to the Eastwards, and it extends to *B*, where I set 2, signifying my second Station; I find next in the East Column 877, which I set in that Parallel from 2 to 3, next in the West Column 859, which I set in that Parallel from 3 to 4: and so I proceed with the rest. And having thus set down the measures in the Meridian and Parallel, we have also as it falls out in this Example two Stations expres'd, namely *A* and *B*,

now

now for the third, I take in the Parallel with my Compasses the distance $A\,3$, and setting one Foot in the Meridian at 3, I strike an Arch neat C, also taking in the Meridian the Distance $A\,3$, and fixing one Foot in the Parallel at 3, I cross the foresaid Arch neat C, the Intersection of these two Arches is the Point C, representing the third Station.

In like sort, I proceed to find the Points $D\ E\ F$ for the fourth, fifth, and sixth Stations, then drawing Lines, namely from the first Station A to the second B, and from the second to the third C, &c. We shall describe the Figure required $A\,B\,C\,D\,E\,F$.

Otherwise whereas here you Add and Substract the several Distances of South and North, as also of East and West by your Compasses, you may with a little more pains Add and Substract them by the Pen, which is the better way.

As having set down in the Meridian the Southerly distance of the third Station 1253, I add thereto 1374, which is against the fourth Station, the sum is 2627; the Southerly distance of the fourth Station, which I set in the Meridian from A to 4. Again, to this I add 521, so have I 3148, the Southerly distance of the fifth Station $A\,5$, from which substracting 1553, the Northerly distance set against the sixth Station, there remains 1595, which is the Southerly distance of the sixth Station, to be set in the Meridian from A to 6. Lastly, from this, abating the Northerly distance of the first Station from the sixth, which I find here also to be 1595, there remains 0. Shewing that I am returned to the same Parallel, or East and West Line, in which at first I began. And in like sort, you may proceed with the East and West Columns, and then by the Intersection of two Arches, find every Station as before.

Other ways might be prescribed, which will not be hard to find of your self. And as we may thus lay down any irregular right-lined Figure far more exactly than by the *Protractor*: So when it is laid down after this manner, we may cast up the *Area* or superficial quantity of it very exquisitely: Yea, if there should be a Plot drawn (according to the Angles and Distances herein given) after the usual manner, by a Scale so large, that the

Plot

not should be an hundred times so great as this; Yet could not the Content thereof be cast up so exactly and certainly as it may be here.

But I must not insist upon these things, they may of themselves be conceived, and my intent is only to touch them, that I be not prevented of time, and by other occasions from handling those things which I have here more specially intended.

But as I have said, this course is chiefly to be used in Plotting large Grounds, and there indeed are graduated Instruments, especially to be used for other smaller grounds, there is none more fit than the *Plain Table*.

CHAP. VI.

Of the Compass of the Earth, and the quantity of a Degree, according to the most approved Experiments Ancient and Modern.

ALthough the Compass of the Earth hath been in some sort observed by divers of the Ancients; Yet for some of them we cannot certainly gather what measures they used; others used no measure at all, but assumed the Distance of places to be such as it was estimated by Travellers to be, and likewise the Latitude; therefore it will be needless to insist upon the examination of their Observations; others of them which were taken by measure, and which we may upon any good Ground reduce to our measures, are these which follow.

Willebrordus Snellius in his Book Entituled *Eratosthenes Batavus*, cites *Abal Fedas*, a most diligent *Arabian* Geographer, that lived about the year of Christ 1320, who records, that about

about the year of Christ 827, certain Men skilfull in the *Mathematicks*, did by the commandment of their Prince *Almanon*, measure in the Fields of *Mesopotamia* (as he gathers) under one and the same Meridian, from the North towards the South, the quantity of a *degr.* and found it to be 56 Miles, or somewhat more. The quantity of their Mile, according to *Alphragranus*, was 4000 Cubits, or 6000 Feet, whence the quantity of a *degr.* should be 336000 Feet; but of the length of their Feet we are something uncertain, only they define it to be so long as the extent of 96 Barley Corns laid side by side, whereas the *Rhynland*-foot, according to tryal by him made, is but the extent of 90 Corns laid in like manner, so that if there be no inequality in the Grains, then 90 *Arabian* Feet are equal to 96 *Rhynland*-feet. But 96 *Rhynland*-feet are found to be about 91 $\frac{1}{6}$ *English* Feet; therefore also, by the Rule of Proportion, 336000 *Arabian* Feet do make of our *English* Feet 370222. So that according to this Experiment of the *Arabians*, a *degr.* should contain 370222 of our *English* Feet. And before we have found by the Observations taken at *London* and *York*, and by the distance of their Parallels measured, that a *degr.* contains of our *English* Feet 367200. The difference is only 3022 Feet, that is, about the $\frac{1}{120}$ part of a *degr.* or half a *min.*

He cites next *Alhazen* the *Arabian*, who in his Book *de Crepusculis*, declares the Compass of the Earth to be 24000000 Paces; so that proportionally there must be in one *degr.* 66666$\frac{2}{3}$ Paces, that is 333333 *Arabian* Feet. And seeing that 90 *Arabian* Feet make of our *English* Feet 99$\frac{1}{2}$, therefore by the Rule of Proportion 333333 *Arabian* Feet, make of our *English* Feet 367283: So that according to *Alhazen*, there should be in a *degr.* 367283 of our *English* Feet, differing from the Experiment which I made only 83 Feet in a *degr.*

I have not strained these numbers to bring them to this nearness, they are the same in effect which are set down by *Snellius* in his *Eratosthenes Batavus*, who with great Industry and Judgement hath compared the measures of the Ancients, and the measures used by several Nations in these times, with the *Rhyn-*

Rhyniand-foot. Much leſs have I ſtrained my own numbers to draw them up to theſe: But on the contrary, I confeſs upon the ſight of his Book, obſerving the great pains and induſtry which he profeſſeth himſelf to have beſtowed, and which I doubt not but he did imploy in making his Experiment, and how he had found the meaſure of a *degr.* to be much leſs than mine, as we ſhall after ſhew, I began to doubt that I had not made ſufficient allowance for the un-evenneſs of the ways, and for ſome ſmall bendings, ſometimes to the right hand, ſometimes to the left, the Obſervation whereof I wittingly neglected, to ſpare time and Expence. For I did often obſerve a Mile or two before me, ſome Mark in the High way noting the *deg.* and meaſuring to it in the way, neglecting to obſerve the intermediate ſwerving of the way, ſometimes three or four *degr.* towards the right hand, ſometimes as much to the left; but making ſuch allowance for that, and for the un-evenneſs as I judged ſufficient. And ſome men may think, that the exact Obſervation of theſe leſſer things thus neglected, and regulated only by judgement or conjecture, might deceive me much: But they may conſider, that if there be two places a Mile diſtant, that is, in a right Line 320 Poles, if you meaſure from one of theſe places towards the other, not in that right Line, but always ſwerving from it by an angle of four *degr.* ſometimes to the right hand, ſometimes to the left, till you come to that other place; I ſay, that notwithſtanding all theſe ſwervings (if there be nothing elſe to augment the meaſure) it will not amount to 321. Now conſidering that I had all the way, as occaſion required, made ſuch allowance as ſeemed convenient, and ſo found 367200 Feet in a *degr.* before I compared it with the meaſures taken by another: I reſolved not to diminiſh nor to augment the numbers thus ariſing by my Obſervations, Meaſures, and Allowances, in reſpect of the Opinions, Obſervations, or Meaſures of any other Man, until there be made ſome Experiment more evident & exact than any yet extant. And I am ſomething the more confirmed by the near agreement of theſe two teſtimonies before recited, both exceeding me a little in the meaſure of a *deg.* But we cannot confi-

dently rest upon them, because of that inequality which may be of Corns or Grains; for theirs may haply be something greater or lesser than ours.

Both these measures of a *degr.* do much exceed the quantity of a *degr.* found by *Snellius*, but when he compares them with his own another way, namely, placing the Barley-Corns so that they may not lie flat, but be set up edge-wise, and so by 96 Corns to make a Foot, and by such Feet to measure a *degree*; then he finds that the quantity of a *Degree*, according to the *Arabians*, is much less than by his Experiment it should be: but if some be laid flat, and others set up edge-wise, the *Arabian* measure of a *degr.* will agree with his. And so he proposeth this doubt, whether the 96 Grains, whereof the *Arabian* Foot doth consist, must lie flat or be set up edge-wise, or some of them to lie flat, and others to be set up edge-wise. But it is most probable that they must lie flat, that being the position which they are apt unto by nature, they cannot be set edge-wise without much trouble, especially so many together as make the length of a Foot, and so the *Arabian* measure of a *degr.* doth near agree to this of mine.

We come next to hear the determination of *Ptolomy* of *Alexandria*, whose authority and credit in the solution of this question, is not inferiour to any of the Ancients. He affirms the Compass of the Earth to be 180000 *Stadiums*, and the quantity of a *degree* 500 *Stadiums*; the same (as *Strabo* saith in his second Book of *Geography*) was before affirmed by *Posidonius*. Also *Marinus Tyrius* (before *Ptolomy*) had determined the quantity of a *degr.* to be 500 *Stadiums*. *Ptolomy* confirms it, not simply from their relations, but as it seems from his own experience, and that by some measures diligently taken, for in the 11 Chap. of the first Book of his *Geography*, he hath these words, *Sed in hoc quoque recte sentit, partem unum, qualium est circulus maximus trecenturum sexaginta; quingenta in terra constituere Stadia, id enim confessis dimensionibus consonum existit.* Also *lib. 7. cap. 5. Ita ut pars una, seu gradus unus quingenta continet Stadia, quemadmodum ex diligentibus deprehensum est dimensionibus.*

Now

Now a *Stadium* not only among the *Greeks*, but as appears by *Herodotus* amongst all other Nations of *Asia* and in *Ægypt*, did consist of 600 Foot; therefore a *Degree* according to *Ptolomy*, must contain 300000 Feet. But the *Ægyptian* or *Alexandrian*-Foot was much greater than our Foot; for as we have before said, the ancient *Roman* Foot is greater than ours, and the *Ægyptian*-Foot was much greater than the *Roman*: For it is often testifyed by *Hero Mechanicus*, that 5 *Alexandrian*-Feet make 6 *Roman*-Feet. And Mr. *Snellius* hath very ingeniously gathered both from *Philandes* and otherwise, that the *Rhyniand*-Foot is equal to the ancient *Roman*-Foot; therefore also 5 *Alexandrian*-Feet are equal to 6 *Rhyniand*-Feet: So that by the rule of Proportion 300000 *Alexandrian*-Feet will make of *Rhyniand*-Feet 360000. But by the size of our *English*-Foot, which was sent him from the Iron Standard in *Guild-Hall*, he finds it to contain but 968 such parts as the *Rhyniand* contains 1000: So that 968 *Rhyniand*-Feet are equal to 1000 *English*, or 121 *Rhyniand*-Feet are equal to 125 *English*-Feet. Therefore also by the Rule of Proportion, 360000 *Rhyniand*-Feet are equal to 371900 of our *English*-Feet. Therefore according to *Ptolomy*, there are contained in a *degree* 371900 of our *English* Feet. But by our fore-mentioned Experiment made between *York* and *London*, we find only 367200 Feet in a *degree*, being less than *Ptolomies* by 4700 Feet, that is, by $\frac{1}{78}$ part of a *degr.* or $\frac{1}{4}$ of a *min.* and little more.

Fernelius a Modern Author and Learned Physician, measuring the way by Revolutions of a Wheel, and the Latitudes by Observation, finds in a *degr.* 68 *Italian* Miles, and 96 Paces, the Pace which he used being more than 5 of our *English*-Feet: But because he handled not the Problem exactly, and is suspected by *Snellius* (though I think without cause) to have grounded his Conclusion rather upon the Experiment of the *Arabians* before set down (wherewith it doth nearly agree) than upon his own, we will insist no longer upon it.

We come in the last place to the Experiment of *Willebrordus Snellius*, a *Hollander*, made in the *Netherlands* about 20 years

past. We shall not need to recite the particulars of it, being extant at large in his Book before mentioned: but in Conclusion, he finds in a *degr.* 342000 *Rhyland*-feet. Now a *Rhyland*-foot (as he hath there shewed, comparing both together) is greater than ours, and that in such proportion, as 1000 is to 968, (and so much or little more it appears to be by that model of the *Rhyland*-foot Printed in his Book) therefore 968 *Rhyland*-feet must make 1000 of ours; and hence by the rule of Proportion, 342000 *Rhyland*-feet, will make of our *English*-feet 353306. So that there should be in a *degr.* only 353306 feet, which is less than we have before found in a *degr.* by 13894 feet, that is, by $\frac{1}{10}$ part of a *degr.* or $2\frac{1}{2}$ *min.* and something more. He was a man doubtless of singular Industry and Knowledge, and of much exercise in the *Mathematicks*, and it may be, was well experienced in this particular, touching the *Geometrical* mensuration of Distances, and he hath bestowed much pains and diligence in this Experiment, as by his Book appeareth. But if he had by a Chain measured the Distance of his two utmost Stations (if the ground would permit, which I suppose it would not) or at least-wise if his measured Stations had been further distant: I conceive he would have found a greater Distance in his two utmost places of Observation. But if a man, intending to find the Distance of two places, measure only the $\frac{1}{100}$ part of that Distance, and by that measured Line and the Angles, think to find their true Distance; whether he do it immediately from those two measured Stations, or immediately by help of others observed from them, he may easily fall into some notable Errour. For though the Problem be exactly true in Geometrical Demonstrations, how small soever the measure be, yet it is not so in sensible and experimental Practices, by reason of the weakness even of the best Eye, and the imperfection of the Instruments in themselves, and in their use. And besides that, there were many Stations obliquely situate; a man cannot always hit the just middle of that Turret, Steeple, or other mark which he observes; neither when he comes to make his Station there, can he always place his Instrument just at the concourse of his former visual

Lines,

Lines, by reason of other Impediments. Besides the force of the wind in such eminent places: and moreover, that amongst so many Steeples as there are in some Towns, there, a man may at some time mistake one for another. And if there should happen no notable Errour, by reason of any or of all these Casualties: Yet may two *min.* in the difference of the Latitude of two places be easily mistaken, especially being derived from the Latitudes of those places which are very rarely set down true to a *min.*

If it be objected, that I might as well be so much mistaken in the difference of the Latitudes of *York* and *London*.

I answer, it is not so likely, because I had the opportunity of observing the Summer Solstitial Altit. of the Sun in both places, wherein I had no necessary use of the Suns Parallax nor Refraction, nor of the Table of the Suns Declination, any of which may cause more than a *min.* Errour, in finding the Latitude of either place.

Besides, if mine Errour in those Observations should be full as much, yet would it not in the Conclusion be half so much, because the difference in Latitude of the two places of my Observation is more than twice so much as that of his.

But let this suffice, leaving every man to embrace that which he shall best approve. Both our Experiments do sufficiently convince that common Error of counting only 300000 *English*-feet to a *degr.* besides the consent of other Observations before recited Ancient and Modern.

M. *Snellius* hath further in that Book of his, Entituled *Eratosthenes Batavus*, with much diligence compared some Ancient measure, as also the measures of sundry Forreign Countreys with the *Rhyland*-foot; and amongst the rest, our *English*-foot, according to a size thereof to him sent from the *Standard* in *Guild-Hall*, (from whence also I had about 20 years past, the size of that Foot, which I have used in this measure,) we shall not need to repeat them all, because his Book is extant: Some of them are these following, which we here compared to our *English*-foot, as he hath there done to the *Rhyland*, that so any of them may be the more easily reduced into our Feet. Therefore dividing the

the *Engliſh*-Foot into a 1000 equal parts, we ſhew how many of thoſe parts are contained in other Ancient and Forreign Feet.

Ancient Feet compared with our *Engliſh* Foot.

Of ſuch parts as the *Engliſh*-Foot contains.		1000
The	Ancient *Roman*-Foot contained	1033
	Ancient *Greek*-Foot contains	1076
	Babylonian contains	1211
	Alexandrian contains	1240
	Antiochean contains	1405
	Arabian contains	1102

Forreign Feet compared with our *Engliſh*.

Of ſuch parts as the *Engliſh*-Foot contains.		1000
The	*Rhynland*-Foot contains	1033
	Dort-Foot contains	1085
	Middlebrough-Foot contains	992
	Amſterdam-Foot contains	934
	Antwerp-Foot contains	939
	Lovain-Foot contains	939
	Hafnian-Foot in *Denmark*	965
	Paris-Foot called the *Kings*-Foot	1090
	Venice-Foot	1157
	Toledo-Foot	896
	Nurimberg-Foot	1006
	Straitsburg-Foot	920

CHAP. VII.

Of dividing the Log-line, *and reckoning the Ships way.*

THere be four things, upon which the Practice of *Navigation* is eſpecially grounded; namely, the knowledge of the Longitude, Latitude, Courſe, and Diſtance. Touching the Longitude, though it may be found by the other

other three, yet hitherto there hath not been delivered any general Rule true and practicable, whereby the Longitudes of places might be immediately and ordinarily found of themselves. The Latitude of places may immediately be found by Observation of the Sun and Stars; as we have formerly shewed in the Appendix to the *Doctrine of Triangles:* The Course by the Compass, the Variation being duly observed, wherein we have many good Mariners very expert, this we have also handled in the *Doctrine of Spherical Triangles.* The Distance run is found of it self by the *Log-line*, whereof we are here to speak.

The ground of finding the Distance run by the *Log-line* is meerly conjectural, being founded upon this Opinion, that 5 of our Feet make a Pace, and 1000 such Paces make a Mile, and that 60 such Miles make a *Degree*; so that a *Degree* should contain 300000 of our Feet: But it appears not only by this Experiment, but even by all others that were diligently taken, and their measures to us known, that there is a greater number of our Feet contained in a *Degree.*

There be three things (as I conceive) that have caused this Errour to be so commonly received and tollerated. The one, for that it doth somewhat counterpoise another contrary Errour in the Practice of *Navigation:* namely, in the use of the *Plain Chart*; for the Errour which is there committed by making every Parallel equal to the Equinoctial, and so every *Degree* in them greater than they should be, is something moderated by this Errour; whereby the measure of a *Degree* is esteemed less than indeed it is.

For Instance; It is evident by the *Globe*, that the Meridians concurring in the Poles grow nearer and nearer together, as they grow towards the Poles; Insomuch, as if two Meridians de distant in the Equinoctial 10 *Degrees*, that is, 600 Miles, the same Meridians in the Latitude of 35 *Degr.* will be distant little more than 490 Miles. Now if unto every Mile we account acoording to the former Experiment 6120 feet, then is the distance of those 2 Meridians in that Parallel near 3000000 feet. In like sort in the *Plain Chart* 10 *deg.* of that Parallel (as of all others) is made

equal

equal to 10 *degr.* of the Equinoctial or Meridian: ſo that the Diſtance of theſe two Meridians will upon the *Plain Chart* be 600 Miles, but one of theſe Miles contains only 5000 feet, ſo that the Diſtance is but 3000000 feet, equal to the former.

And although theſe Errors in other caſes do not juſtly ballance one another, as in this Example, yet that of the *Plain-Chart* is always ſomething moderated by this other, and ſo much the more by how much they are nearer to the foreſaid Latitude. I grant that this is only ſo when the Courſe is near unto the Eaſt or Weſt Points; but withal, I ſay that this kind of reckoning is (in a manner) then only uſed: For he that runs any Courſe near the Meridian Southerly or Northerly, hath a more certain way of reckoning; namely, his Latitude, which he finds daily by Obſervation of the Sun and Stars, upon which he will depend, either neglecting, or at leaſt not regarding his dead reckoning. Yea, (if it may be) never caſting the *Log* ſo much as once in ſuch a Voyage, having a more ſure ground for his reckoning. But in a Courſe that is near the Eaſt and Weſt, (foraſmuch as there is no way diſcovered for finding the Longitude) he is driven of neceſſity to make uſe of his dead reckoning.

We might add moreover, that the principal Voyages of this kind, I mean of thoſe which conſiſt of Courſes much Eaſterly and Weſterly, as to and from the *Weſt-Indies*, and the Parallel of *Cape bon Eſperance* are near unto this Latitude of 35 *degr.* ſo that as ſome of them are more Southerly, others of them are more Northerly.

But to inſiſt no longer upon this, I ſuppoſe a ſecond cauſe to be, for that Men commonly deſire to have their reckoning before their Ship (as they ſay) that they fall not with a place before they look for it; And this comes ſo to paſs, whilſt the Miles are accounted leſs in meaſure, and ſo more in number than they are indeed.

And thus, though there may ſeem to be ſome commodity in theſe Errours, eſpecially when they do nearly ballance one another: Yet becauſe they ſeldom do ſo, but always leave men in uncertainties, and oftentimes in great perplexity and danger, it

is

is much safer and better to reject them both, and to imbrace those ways, which are evidently grounded upon truth, though there may be in them some more difficult at the first. Yet I confess, that he which reforms one and not another, may sometimes erre so much the more thereby. And I doubt not, but many would reform them both, if they could certainly do so.

Therefore a third cause of admitting and retaining this Error seems to be, for that there hath been no way delivered from evident and certain Grounds for the rectifying of it. I doubt not but many have found Errours in their Reckonings arising from hence, that they account only 300000 of our Feet to a *Degree*; but not knowing certainly where to lay the fault, have imputed it sometimes to ill Steerage, otherwhiles to the Variation of the Needle, or to some mistake in the Reckonings, or to some error in their Plots, or to some Current, or such other accident, and so the Errour hath rested unreformed. Wherefore although the practical performance of this Problem for finding the Circumference of the Earth, or the quantity of a *Degree* on the same, have many singular uses which I cannot now touch; yet that which amongst the rest I chiefly aimed at, was, that we might have a more sure and evident ground for dividing the *Log-line*, and for reckoning the Ships way or distance run more truly upon any Rumb or Point of the Compass than formerly.

And now to apply it to this purpose, we have noted before (*Chap.* 2.) that by the experiment there expressed, we find in a *Degree* on the Circumference of the Earth and Sea, 367200 of our *English* feet. Wherefore retaining still the same division of a *Degr.* into 60 miles or 20 Leagues (as hath been formerly used) a Mile will contain 6120 Feet, or 1020 Fathoms: And so a League contains 18360 Feet, or 3060 Fathoms; for dividing 367200 by 60, the Quotient is 6120, *&c.* Thus then 60 Miles being a *Degree*, every Mile is 6120 Feet.

Now supposing the time of the running out of the *Log-line* to be measured by an half Minute-glass, if we observe how many Feet or Fathom she runs in half a Minute; we may thereby find her way for an hour or 4 hours, or for any other time proposed.

As admit there runs out of the *Log-line* in half a minutes ſpace 51 Feet, or 8½ Fathoms, and you would know what way the Ship makes every hour after the ſame rate;

Say by the Rule of Proportion;

If 0½ Minutes, give 51 Feet,

What gives 60 Minutes; Or,

If 1 Minute gives 102 Feet:

What gives 60 Minutes?

And ſo Multiplying, you ſhall find 6120 Feet, which is one Mile. Or, if you would find her way for 4 hours, which is 240 minutes; ſay,

As 1 minute, is in proportion to 240 minutes,

So are 102 Feet, to 24480 Feet, or 4 miles.

Or if you would have it in Fathoms, ſay,

As 1 minute is in proportion to 240 minutes;

So is 17 Fathoms, to 4080 Fathoms, the Ships way in four hours. The like is to be conceived, if your Glaſs be for any other quantity of time above or under half a minute.

Some have thought that the way which the Ship maketh, may be known to an old Sea-man by experience (as they ſay) that is by conjecture: Which Opinion makes ſome neglect the uſe of the *Log*, leſt they ſhould be accounted young Sea-men. But as he that rides often will have ſome near gueſs how far the pace he rides will carry him in an hour (becauſe he hath often obſerved it formerly) ſo he which hath often Sailed and kept an account of the Ships way by the *Log*, will be able to give ſome near eſtimate of her way without the *Log*. But it is incident to ſome men to have ſuch a conceit of this their eſtimate, that they think it more certain than the Rule it ſelf, from whence it is derived, eſpecially if it chance to anſwer their expectations at ſome times.

It is thought alſo that the Ships way may be known by two Marks on the Ships ſide, but this is doubtleſs very uncertain, both by reaſon of the ſhortneſs of the time, and in reſpect of the dead water (as they call it) by the Ships ſide. For the water which is near the Ship, is drawn along with the Ship in her

her motion, and ſo much the more, by how much it is nearer.

But if any deſire to make tryal of this way, it is to be conſidered, that 17 Foot is $\frac{1}{360}$ part of a mile, and 10 *ſec.* of a minute is $\frac{1}{360}$ part of an hour: Therefore if there be two Marks on the Ships ſide diſtant 17 Feet, if the Ship run the diſtance of theſe two Marks in 10 *ſec.* ſhe runs a mile an hour, if in 5 *ſec.* two miles an hour, if ſhe runs that diſtance in 2 *ſec.* ſhe runs 5 miles an Hour. And ſo always dividing 10 *ſec.* by the number of *ſec.* in which the Ship runs in that diſtance, the Quotient ſhews the miles and parts of a mile run in an hour.

But if the diſtance of thoſe two Marks be 34 Feet, if ſhe run it in 20 *ſec.* it is after a mile an hour: if in 10 *ſec.* two miles an hour, if in 5 *ſec.* four miles an hour: and ſo always dividing 20 *ſec.* by the number of *ſeconds*, in which the Ship runs that diſtance, the Quotient ſhews how many miles the Ship runs in an hour. As if the Ship run that diſtance of 34 Feet in 8 *ſec.* then dividing 20 by 8, the Quotient is $2\frac{1}{2}$, ſhewing that ſhe runs $2\frac{1}{2}$ miles in an hour. Or, if you can conveniently make the diſtance of the two Marks on the Ships ſide to be 51 Feet (for the further they are diſtant, the better) then if the Ship run that diſtance in 30 *ſec.* it is a mile an hour, if in 10 *ſec.* it is 3 miles an hour, and ſo always dividing 30 *ſec.* by the number of *ſeconds*, in which the Ship is running that diſtance, the Quotient ſhews after that rate how many miles the Ship runs in an hour.

Otherwiſe you may do thus, Divide 17 Feet into 10 parts, and ſet as many of thoſe parts on the Ships ſide, as conveniently you may, (which according to the Ships length will be more or fewer. Then when the Ship runs one of thoſe parts in a *ſec.* of time, it is a mile an hour: when two, it is two miles an hour; when 5, it is 5 miles an hour. And in general, if you divide the number of parts run by the time of running accounted in *ſec.* the Quotient ſhews what number of miles after that rate are run in an hour.

As if ſhe run 30 of thoſe parts in 5 *ſeconds*, it is 6 miles an hour; for dividing 30 by 5, the Quotient is 6, ſo if ſhe run 42 of thoſe parts in 10 *ſeconds*, dividing 42 by 10, the Quo-

tient is $4\frac{5}{6}$, which sheweth the Ships way at that time to be after the rate of four Miles and two tenths of a Mile in an hour.

But for keeping this account of time, it may be done either by a Sand-glass for that purpose, or by pronouncing certain words or numbers: as the time wherein a man tells twice 60, pronouncing every number as fast as he can conveniently and distinctly, is about a Minute; so that the time wherein a Man is numbring 60, is half a Minute or 30 *seconds*; and whilst a Man is numbring two (as one and twenty, two and twenty) is a *second*, and so whilst a Man is numbring from twenty to thirty, is five *seconds*, from twenty to forty, ten *seconds*, &c. but in numbring from one and twenty, you may observe the same times as in numbring from one and twenty to forty, and this will not be hard to do; for whilst a man pronounceth one and twenty, two and twenty, three and twenty, *&c.* there remains a certain Impression in the Fantasie, whereby a man is able in the same times to pronounce one, two, three, *&c.* And although this rule of numbring twice 60 for a Minutes space, be not general unto all men, because some are swifter or slower in their pronunciation than others; yet after this Example, a man making tryal, may frame a Rule to himself, whereby he may come something near the truth.

But leaving these, we come to the division of the *Log-line*, according to the half Minute-glass, which is more usual and certain. And considering that half a Minute is of an hour the $\frac{1}{120}$ part, therefore the Ships way running 51 Feet in half a Minute, is a Mile an hour; if she run twice so much, that is, 102 Feet in half a Minute, it is two Miles an hour; if thrice so much, it is three Miles an hour; and in general, how many times 51 Feet she runs in half a Minute, so many Miles is her way for an hour. Therefore leaving half a score Fathoms, or more from the *Log*, that so it may be out of the *Eddy* of the Ships wake, before you begin to account or turn the Glass; if there you make a Mark for the beginning, and so 51 Feet from thence a Mark of one Knot, and 51 Feet further a Mark of two Knots, and 51 Feet further (that is, 153 Feet from your first Mark), another

Mark

Mark of three Knots, and ſo proceeding; look how many Knots are veered out in half a Minute, ſo many Miles is the Ships way for an hour. Now for that which is veered out more above the juſt meaſure of a Knot or Knots, you may allow for every five Feet the tenth part of a Mile almoſt. As admit ſhe run 5 Knots, and 25 Feet in half a Minute; then is her way according to $5\frac{1}{10}$, or five Miles and an half in an hour, if ſix Knots and ten Feet, it is $6\frac{2}{10}$ miles in an hour, *&c.*

But according to the common Opinion of 5000 Feet to a Mile, and 60 ſuch Miles to a *Degree*, there ſhould be ſomething leſs than 7 Fathom, namely, $41\frac{2}{3}$ Feet to a Knot.

And although he which veers the *Log-line* be careful to overhale it ſo ſlack, that it may not draw forwards the *Log*, yet (no doubt) it doth loſe ſome way, following the Ship a little as it is drawn by the Line, and withal by the *Eddy* of the Ships wake, and ſometimes alſo is caſt forwards by the Wind and Waves, when they come after the Ship; ſo that for theſe cauſes, it is like, there may ſometimes be allowed three or four Fathoms more then is veered out; but this (as a thing mutable and uncertain) being ſometimes more, ſometimes leſs, cannot be brought to any certain Rule, but ſuch allowance may be made for it as a man in his experience and diſcretion finds fit.

If you would divide the *Log-line* ſo as it might give the Ships way in *Centeſmes*, or the hundredth part of a *Degree*, and fit it to a half Minute-glaſs, Then ſeeing the hundredth part of a *degree* is 3672 Feet, and the $\frac{1}{120}$ part thereof is $30\frac{3}{5}$ Feet; If you begin at the mark at which you mean to turn the Glaſs, and meaſure from thence 30 feet, and 3 fifth parts of a Foot, you may there place 1 Knot; and thence again meaſuring 30 Feet, and 3 fifth parts of a Foot, there place 2 Knots; and ſo proceeding at the end of every 30 Feet and 3 fifths, adding a Knot, the number of Knots which run out in half a Minute, is the number of *Centeſmes* which the Ship runs in an hour. As ſuppoſe there run out ten Knots in half a Minute, then the Ships way according to ten *Centeſmes* to a *degree* in an hour, that is, the tenth part of a *Degree*, or ſix Miles. And ſo every three Foot above the

juſt

juſt meaſure of Knots, is near the tenth part of a *Centeſme*, or the 1000*th* part of a Degree. As if there run out of the *Log-line* 5 Knots and 12 Feet, then the Ships way for an hour is 5 *Centeſmes*, and four tenth part of a *Centeſme*: the like is to be underſtood of others.

And after the form of theſe Examples you may divide the *Log-line* for any other quantity of Time, more or leſs than half a minute, or for any other parts of a Degree propoſed.

Thus have we handled the Diviſion of the *Log-line*, according to the meaſure before found of 367200 *Engliſh* feet in a Degree: But becauſe (as I have before ſhewed) the Ships way is commonly more than by the *Log-line* it appears to be, and every man deſires to have his reckoning ſomething before his Ship, that he fall not with a place unexpected; for theſe, and ſuch other cauſes; and for the rotundity of the number, if any man think it more ſafe and convenient in Sea-reckonings, he may abate one in 51, and ſo aſſign to a Degree only 360000 Feet, and conſequently to a mile 6000 *Engliſh*-feet.

And upon this ground, if in half a minute there run out 50 Feet of the *Log-line*, it is a mile an hour; and ſo if 100 Feet run out in a minute.

For, as 1 minute is in proportion to 60 minutes:
So is 100 Feet to 6000 Feet.

And ſo foraſmuch as twenty five Feet is $\frac{1}{240}$ part of a mile, and 15 *ſeconds* is alſo $\frac{1}{240}$ part of an hour: Therefore if there be two Marks on the Ships ſide diſtant 25 Feet, if the Ship run the diſtance of theſe two Marks in 15 *ſeconds*, it is after the rate of a mile an hour; if in 5 *ſeconds*, it is 3 miles an hour; and ſo always dividing 15 *ſeconds* by the number of *ſeconds* in which the Ship runs that diſtance; the Quotient ſhews the miles and parts of a mile run in an hour. But if the diſtance of theſe two Marks be 50 Foot, then if ſhe run it in 30 *ſeconds*, or half a Minute, it is a mile an hour; if in 10 *ſeconds*, 3 miles an hour; if in five *ſeconds*, ſix miles an hour, (for 30 divided by five, the Quotient is 6.) And ſo always dividing thirty *ſeconds* by the number of *ſeconds*, in which the Ship runs that Diſtance;

ſtance; the Quotient ſhews how many miles ſhe runs in an hour, *&c.*

Otherwiſe, if you make a mark on the Ships ſide at every twenty Inches, then when the Ship runs one of theſe parts in a *ſecond* of time, it is a mile an hour: when five, it is five miles an hour: if ſhe run 18 of theſe parts in three *ſeconds*, it is ſix miles an hour. For dividing 18 by 3, the Quotient is ſix. And in general, if you divide the number of the parts run, by the number of *ſeconds* ſpent in running, the Quotient ſhews the Ships way in Miles for an hour.

But for dividing the *Log-line* according to this ground of 6000 Feet in a Mile, if you intend to uſe it with a half Minute-glaſs; then becauſe half a Minute is $\frac{1}{120}$ part of an hour, and 50 Feet is alſo the $\frac{1}{120}$ part of a Mile: Therefore when the Ship runs 50 Feet in half a Minute, her way is after the rate of a Mile an hour; if 100 Feet in half a Minnute, it is two Miles an hour, *&c.*

Therefore half a ſcore Fathoms or more from the *Log*, you may make a Mark, and beginning from thence meaſure 50 Feet, and there make the firſt Knot, and 50 Foot farther two Knots, and 50 Foot farther three Knots, and ſo proceeding: Look how many Knots is run out in half a Minute, ſo many Miles is the Ships way for an hour: and every 5 Feet more beſides the Knots, is a tenth part of a Mile; as if there run out 6 Knots and 20 Feet in half a Minute, the Ships way is after the rate of $6\frac{2}{10}$ Miiles in an hour, *&c.*

And ſo if the Glaſs were for any other time more or leſs than half a Minute, you may make the diſtance of your Knots proportional: as if it were for 20 *ſeconds*, then becauſe 20 *ſeconds* is of an hour the $\frac{1}{180}$ part, I divide a Mile, which is 6000 Feet, by 180, and the Quotient is $33\frac{1}{3}$; therefore there muſt be a Knot at every 33 Feet and 4 Inches.

If your Glaſs be 36 *ſeconds*, which is $\frac{1}{100}$ part of an hour, divide 6000 by 100, the Quotient is 60, ſhewing that there muſt be 60 Feet to every Knot, and then every 6 Foot over and above the Knots, is a tenth part of a Mile more.

And

And ſo it is better that your Glaſs be more than half a Minute rather than leſs; and the more the better, provided that there run out no more Line then you may hall in again, without danger of breaking.

Laſtly, if you would ſo divide the *Log-line*, that it might ſhew the Ships way in *Centeſmes* of a *degree*, and fit it to an half Minute-glaſs, Then foraſmuch as the hundreth part of a *degree* is 360 feet, and the $\frac{1}{120}$ part thereof is 30 feet; therefore beginning at the mark whereat you intend to turn the Glaſs, meaſure from thence 30 feet, and there make one Knot, and at 30 feet farther two Knots, *&c.* Then look how many Knots run out in half a Minute, ſo many *Centeſmes* of a *degree* is the Ships way for an hour. And ſo if the Glaſs be 36 *ſeconds*, then every Knot muſt have 36 Feet, *&c.*

Now if a man Sailing between any two places which lie near Eaſt and Weſt one from another, have kept his Reckoning by Courſe and Diſtance, uſing a *Log-line* ſo divided, that it have a Knot at every 7 Fathoms (as many do) and would reduce the Diſtance of thoſe two places ſo found, to their Diſtance in ſuch Miles, as theſe of 60 to a *Degree*, each containing (as we have ſaid) 6000 feet: The proportion in number of thoſe to theſe, is as 6 to 5, for 6 of them make 5 of theſe.

As admit a man in his dead Reckoning, uſing ſuch a *Log-line* as hath a Knot at every 7 Fathoms, and for every Knot running out in half a Minute, he accounts the Ships way to be ſo many miles an hour; and according to ſuch a Reckoning, ſuppoſe he find the diſtance of two places to be 1224 miles, or 408 Leagues, and would know the Diſtance of the ſame places in miles of 6000 Feet to a Mile, which is according to a *Log-line* that hath a Knot at every 50 Feet.

Say then by the Rule of Proportion;

As the number 6	*Co. ar.*	9.22185
Is in proportion to 5		0.69897
So is the number of miles given 1224		3.08778
To the number of miles required, 1020		3.00860

Which

Which 1020 is the diſtance of thoſe two places, in ſuch Miles whereof 60 make a *degr.* Or to find the ſame in Leagues, the Proportion is; As 6 to 5; ſo is 408 Leagues, to 340 Leagues.

And thus may the Diſtance of Places be found in ſuch Miles, whereof 60 make a *degr.* eſpecially if with the diſtance expreſſed in the *Plain Chart*, you compare the reckonings of ſome skilful Mariners that have Sailed from the one to the other. But thus to endeavour a Reformation of the *Plain Chart*, were a Labour to little purpoſe; For there the correcting of the true ſituation of two places, in reſpect of one another, is oftentimes an occaſion that the ſame places are the more falſly ſituate in reſpect of others. Like as if there were two places 8 miles diſtant, and it were required to place a third three miles from either of them; Here if we ſet the third in the middle, it will be four miles diſtant from either: But if (attempting to mend that Errour) we make the third to be 3 miles from the firſt, then will it be 5 miles from the *ſecond:* And thus unavoidably, the mending of the one, is the marring of the other; becauſe the thing propoſed is not poſſible.

And ſuch is the Errour of the Plain or common *Sea-Chart*, repreſenting the Earth and Sea, not as a Spherical, but as a Plain *Superficies*; not as if the Meridians did concur in the Poles, but as if they were always parallel one to another. So that the graduation and projection being ſuch, the Situations and Diſtances of places, cannot be generally and truly expreſſed therein.

But the graduation and Projection of *Mercators Chart*, agreeing without ſenſible errour with the *Globe*, there may in that be deſcribed all or any parts of the World, according to their Longitudes, Latitudes, Courſes, and Diſtances, as truly, and far more conveniently for the *Mariners* uſe then upon the *Globe* it ſelf; and upon ſuch a *Chart* ſo deſcribed, a reckoning may be truly kept, and any Errour committed may eaſily be diſcerned and amended. Whereas on the *Plain Chart*, if a man find his reckoning to diſagree, he is ſo far from knowing how to amend it, that he can ſeldom conjecture where the fault was.

The neglect and want of these *Charts* hath been, and is a great imperfection in *Navigation* and *Geography*. For howsoever there be some which do daily set forth to sale Maps of the World, and of the parts thereof, according to this Projection: Yet to have them truly such, and fit for *Navigation*, requires in the Author or maker of them good knowledge, and some competent ability of his own, or aid from others, with a greater love to the Truth, than to his own Profit, which may induce him to bestow such Industry, Time, and Expence, as I have formerly noted to be requisite in such a Work.

For the furtherance whereof, and of the Practice of *Navigation* in general, I shall endeavour in the two next Chapters to shew a methodical and orderly way of keeping a reckoning at Sea, more distinctly and exactly than hath been formerly used, and such as may aptly be set down in any *Chart*, and applyed in the three principal kinds of Sailing; namely, according to the *Plain Chart*, or *Mercator's*, or according to the Arch of a great *Circle*. And by a few reckonings truly set down, according to this form, the Maps of the World, and of the parts thereof, might be much reformed.

CHAP. VIII.

A formal and exact way of setting down and perfecting a Sea-reckoning.

ALthough the Course and Distance cannot be so truly and certainly known as the Latitude may be: yet we must endeavour in these also to come as near the Truth as may be, the rather for that some reckonings must necessarily depend wholly upon them. And to that end, those which in their Voyages at Sea have occasion to run far upon any Course or Courses near the Meridian, may do well to make tryal of that which I have formerly set down, touching the quantity

tity of a *degr.* on the Earth and Sea in our known Measure; and especially in *East-Indian* Voyages, Sailing from the *Lizard* in the West part of *England*, to *Cape bonne Esperance* in *Africk*, they have opportunity of making an ample Experiment hereof.

But leaving this to the Practice of the skilful and industrious *Sea-man*, we come now to shew an orderly and exact way of framing and keeping a reckoning at Sea: for which purpose I have made the *Table* following, which sheweth how much a Ship is more Northerly or Southerly, and how much more Easterly or Westerly, by Sailing upon any Point or half Point of the *Compass*, any number of Miles proposed.

The like *Table* I made many years since, and taught the Use of it in *Navigation*; whether it were then used by any other, I know not, I had it of no Man; but this I speak, that if any Man claim the first Making and Use of such an one, he may have it.

The Ground of making this *Table* is the same with the former. *For as* Radius *is in proportion to the Distance run, So is the Sine Complement of the* Rumb, *to the Distance of North or South, and so is the Sine of the* Rumb, *to the Distance of East or West.* Therefore here for 10 Miles upon any of the four Points from the Meridian, we set in the second Column the Sine Complement of that Point (reduced into *degr.*) and in the third the Sine thereof. As the second Rumb or Point from the Meridian, being 22 *degr.* 30 *min.* the Sine Complement thereof which is 9239 set in the second Column against 10: and the Sine thereof 3827, I set there in the third Column, and having done thus for 10 Miles in every Column, the rest may be easily drawn from them.

As in the second Column, for the first half Point against 10 Miles finding 9952, I set the half thereof; namely 4976 against 5 Miles, and the tenth part thereof, namely, 995 against one Mile, which doubled or added to it self, is 1990, to be set against two Miles, whereto adding the same 995, the Sum is 2985 for three Miles; and so for the rest.

And thus for every Point and half Point from the Meridian, there are three Columns: In the first whereof there is set down a number of Miles run upon that Point or half Point; the *second* sheweth how much the Latitude is altered; that is, how much you are more Southerly or Northerly, by running so far upon that Point or half Point; the third, how much you are more Easterly or Westerly, by running that Course and Distance.

The numbers set in every first Column from 1 to 10, are also to be understood from 10 to 100, or from 100 to 1000, and the Figure in the fourth place of the second and third Colums, answer to the Figure in the first. As admit a Ship run South and by West (that is (South 1 Point Westerly) 165 Miles,) I set down this number thus; and looking in the Columns of the first *Rumb* against 10 (which may be understood to be 100 (I find against it in the second Column 981 almost, and in the third 195, also against 60 (that is 6) in the first Column, there is 588 in the second, and 117 in the third: also against 5 in the first Column, there is 49 in the second, and almost 10 in the third.

	100	981	195
S.W. 1.	60	588	117
point.	5	49	10
	165	161.8	32.2

These set down, and summ'd up as here appeareth, shew that a Ship running *S* by *W* 165 Miles, is to the Southwards of the place from whence she departed 161 Miles, and 8 Tenth parts of a mile, and to the Westwards 32 miles, and 2 Tenth parts of a mile. If you desire more exactness, you may use all the places for the first or greatest number, which is here 100.

	100	9808	1950
S.W. 1.	60	5885	1170
point.	5	490	97
	165.	161.83	32.17

As in this second Example, where the Southerly Distance is 161 $\frac{83}{100}$ miles, and the Westerly 32 $\frac{17}{100}$ miles.

A Table

A Table of the Northing or Southing, Easting or Westing of every Rumb and half Rumb from the Meridian; according to the number of Miles run upon that Rumb.

	½ point.	7½ poin.	1 poin.	7 point.	1½ poin.	6½ poin	2 point.	6 point
M	5. 37½	84. 22½	11. 15	78. 45	16. 52	73. 7½	22. 30	67. 30
1	995	98	981	195	957	290	924	383
2	1990	196	1962	390	1914	580	1848	766
3	2986	294	2943	585	2871	879	2772	1148
4	3981	392	3923	780	3827	1161	3696	1531
5	4976	490	4904	975	4784	1451	4620	1914
6	5971	588	5885	1170	5741	1741	5544	2297
7	6966	686	6866	1365	6698	2031	6468	2680
8	7961	784	7846	1560	7655	2221	7392	3062
9	8957	882	8827	1755	8612	2612	8315	3445
10	9952	980	9808	1950	9569	2902	9239	3827

	2½ poin.	5½ poin.	3 point.	5 point.	3½ poin	4½ poin.	4 point.	4 point.
M	28. 7½	51. 52⅔	33. 45	56. 15	39. 22½	50. 37½	45. 00	45. 00
1	882	471	831	556	773	634	707	707
2	1764	942	1663	1111	1546	1269	1414	1414
3	2646	1414	2494	1667	2319	1903	2121	2121
4	3528	1885	3326	2222	3092	2538	2828	2828
5	4410	2357	4158	2778	3865	3172	3535	3535
6	5292	2828	4989	3334	4638	3806	4242	4242
7	6174	3300	5820	3890	5411	4440	4949	4949
8	7056	3771	6652	4445	6184	5075	5656	5656
9	7937	4243	7483	5000	6957	5710	6364	6364
10	8819	4714	8315	5556	7730	6344	7071	7071

A larger Example may be that before set dow in the last *Problem* of Sailing by a *Great Circle* from *Summer's-Islands* to the *Lizard*, pag. 127.

As

As admit I Sail from thence; First, N E ½ Point Easterly 600 Miles, then *N E* by *E* 300 Miles; East North-east half a Point Northerly 495 Miles; *E N E* 390 Miles, *E N E* ½ Point Easterly 264 Miles; *E* by *N* 210 Miles; East 951 Miles: These Courses and Distances I set down in such form as here appeareth, where in the first Column there is expressed the Course or Point of the Compass upon which a Man Sails: In the second Column, the Distance of that Rumb from the Meridian: In the third Column, the Distance run upon that Point; In the rest, the difference of Latitude, and departure from the Meridian in Miles, and tenth parts of a Mile.

Course.	*Rumb from me.*	*Dist. miles.*	*North.*	*South.*	*East.*	*West.*
E N ½ Po. *E.*	*North Easterly.* 4 ½ P.	600	380.6		463.8	
N E by *E.*	*N East* 5 Point.	300	166.7		2494	
E N E ½ Po. *N.*	*N East* 5 ½ Po.	400	1885		3528	
		90	424		794	
		5	24		44	
E N E	*N East* 6 Point.	300	1148		277.2	
		90	344		831	
E N E Po. *E.*	*N East* 6 ½ Point.	200	580		1914	
		60	174		574	
		4	12		38	
E by *N*	*N East* 7 Point.	200	390		1962	
		10	20		98	
East.	*East.*	900			9510	
		50				
		1				
		3210	1047.4		29197	

(In

(In all which is to be conceived, that the *Variations* are allowed) ſo that at the Foot of this reckoning, I find the Sum of the North Column to be 1047 $\frac{4}{10}$ Miles, and the Sum of the Eaſt Column 2920 Miles almoſt; the firſt, namely, 1047 miles converted into *degr.* is, 17 *degr.* 27 *min.* the difference of Latitude, which added to the Latitude of *Summers Iſlands* 32 *deg.* 25 *min.* (where this reckoning began) the Sum is 49 *deg.* 52 *min.* which is the Latitude of this laſt place where this reckoning endeth. So that according to this Account, the Ship is run into the Latitude of 49 *deg.* 52 *min.* and hath altered her Longitude to the Eaſtwards 2920 miles, of ſuch miles, whereof 60 make a *degr.* of a great Circle.

Therefore, if you ſet down this reckoning on the *Plain Chart*, you muſt make a Point in the *Chart* that may be in the Latitude of 49 *deg.* 52 *min.* and to the Eaſtwards of *Summers Iſlands*, (where this reckoning began) 2920 miles, that is, you muſt run a parallel (with your Compaſſes or otherwiſe) on your *Chart* in the Latit. of 49 *deg.* 52 *min.* and croſs the ſame by a Meridian, which may be to the Eaſtwards of the Merid. of *Summers-Iſlands* 2920 miles, and ſo the Point of the Interſection of this Parallel and Meridian, is the Traverſe-point or Point in the *Chart* repreſenting the place where the Ship is in the end of this reckoning.

But if you ſet down this reckoning on *Mercator's Chart*, you muſt alſo find a Point that may be in the Latitude of 49 *deg.* 52 *min.* and may likewiſe be to the Eaſtwards of *Summers-Iſlands* 2920 miles, which is done by running with your Compaſſes a Parallel in the Latitude of 49 *degr.* 52 *min.* and croſſing the ſame by a Meridian, which may be to the Eaſtwards of the Meridian of *Summers-Iſlands*, 2920 miles, the Point of the Interſection of this Parallel with that Meridian, is the Traverſe-point, repreſenting in the *Chart* the place where the Ship then is.

For it is to be conceived in this *Chart*, that the *degrees* of the Meridian intercepted between the Latitudes of two places are as a Scale for thoſe two places, to meaſure not only their difference of Latitude, but likewiſe their Diſtance in their Rumb, as alſo the Diſtance of their Meridians.

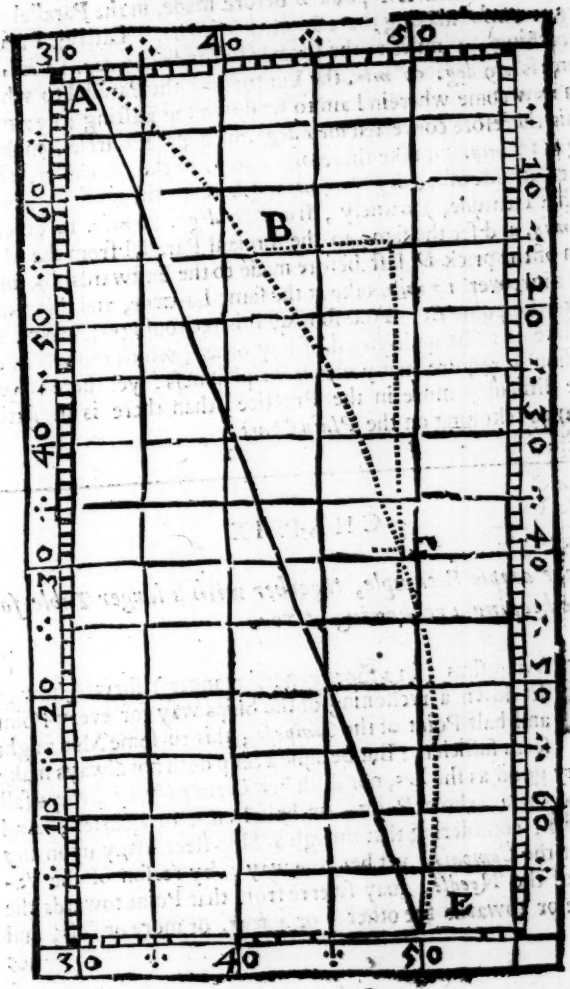
But

But becauſe it often falls out, that in Sailing from place to place, a Ship runs not near the Rumb of the two places by many hundred miles, eſpecially in ſailing by the Arch of a *great Circle*, which is the moſt exquiſite manner of Sailing, and wherein a man ſhifts his Courſe often, and runs much farther in one Latitude than in another, as by the former Example may appear. Therefore once in three or four days, or ſo often as you alter your Courſe much, you may tranfer or ſet down your Reckoning out of your Book into your *Chart*. As in transferring the former Example, you may ſet down the Northing and Eaſting of every of the Courſes ſeverally; but for brevity ſake we will bring them into three parts (and ſo alſo we ſhall not much err.

And thus for the two firſt Courſes, namely *NE* $\frac{1}{2}$ Point Eaſterly 600 miles, and *NE* by *E* 300 miles, I find in the North Column 547 Miles; and in the Eaſt Column 713 miles; alſo for the three next Courſes, ſumming up the North and Eaſt Columns, I find the Northing to be 459 miles; and the Eaſting 1050 miles. Alſo for the two laſt Courſes, I find the Northing to be 41 miles, and the Eaſting 1157 miles.

North.	*Eaſt.*
547	713
459	1050
41	1157
1047	2920

Now to transfer theſe into the *Chart*, I conſider that 547 miles is 9 *degr.* 7 *min.* which added to the former Latitude 32 *degr.* 25 *min.* makes Latitude 41 *degr.* 32 *min.* In which Latitude I run a Parallel, then conſidering that 713 miles is 11 *degr.* 53 *min.* I take this 11 *degr.* 53 *min.* in the Meridian, as much above the one Latitude, as beneath the other, namely, from 31 *degr.* 0 *min.* to 42 *degr.* 53 *min.* and this I ſet in the foreſaid Parallel from the Meridian of *Summers Iſlands* to the Eaſtwards, and there make the Point *B*, then reducing 459 miles into *degr.* it makes 7 *deg.* 39 *min.* which added to 41 *deg.* 32 *min.* makes Latitude 49 *deg.* 11 *min.* Alſo the Eaſting 1050 miles are 17 *deg.* 30 *min.* the half whereof 8 *deg.* 45 *min.* I take in the Meridian from above 41 *deg.* 32 *min.* beneath 49 *degr.* 11 *min.* namely, from 41 *deg.* 20 *min.* to 50 deg. 5 *min.* And this being doubled (becauſe it is but the half) I ſet from the Meridian of the


30
40
50
A
B
E
60
50
40
30
20
10
10
20
30
40
50
60

the Prick or Traverſe-point *B* before made, in the Parallel of 49 *deg.* 11 *min.* making there another prick *D*. Laſtly, I add the Northing 41 miles to the former Latitude 49 *deg.* 11 *min.* the Sum is 49 *deg.* 52 *min.* the Latitude of the Parallel to which I am now come, wherein I am to ſet down the Eaſting 1157 miles. This therefore converted into *degr.* of a great Circle, make 19 *degr.* 17 *min.* I take therefore 1 *degr.* of the Meridian, about that Latitude of 49 *degr.* 52 *min.* (becauſe the moſt part is run in that Latitude,) namely, from 49 *degr.* 30 *min.* to 50 *degr.* 30 *min.* and ſet the ſame in the foreſaid Parallel from the Meridian of the prick *D*, laſt before made to the Eaſtwards 19 times, and moreover 17 *min.* take at the ſame Latitude, and this reacheth to the point *E*. And ſo is all this reckoning ſet down, and the like is to be underſtood of any other, which though in expreſſion it require many words for plainneſs, yet there is very little difficulty more in the Practice, than there is in ſetting down a reckoning on the *Plain Chart*.

CHAP. IX.

A more ample Example, together with a larger Table for the keeping a reckoning at Sea.

HAving thus (in a more general manner) ſhewed how to ſet down a reckoning, or the Ships way for every Point and half Point of the *Compaſs*; this to ſome Men might ſeem ſufficient: But, becauſe a Ship doth not always make her way good as ſhe lies, nor doth her *Leeward*-way always fall juſtly upon a whole Point, or half-Point, or quarter; And moreover, conſidering that though a Ship ſteer away upon any Point of the *Compaſs*, yet her true way, by reaſon of the Variation of the *Needle*, may ſwerve from that Point towards the one ſide or towards the other 3 or 4 *degr.* or more or leſs, and

not always a Point, or half a Point, or quarter: therefore I have thought it requiſite to ſet down the Table following to every ſingle *degr.* and that a man might the more readily with one or two Entrances have his deſire; I have alſo enlarged the number of miles unto 100. The Ground and way of making this Table differs not from the former, and it is to be uſed almoſt in the ſelf ſame manner: wherefore we ſhall uſe the more brevity in handling of it.

Here followeth a Table of the Northing or Southing, Eaſting or Weſting of every *degr.* from the Meridian, according to the number of Miles run upon that *deg. which for brevity ſake we call* ——

A

TABLE

FOR THE

DIFFERENCE

OF

LATITUDE,

AND

Departure from the *Meridian.*

M.	1 d.	89 d.	M.	1 d.	89 d.	Min.	1 d.	89 d.
1	10	0	35	350	6	69	690	12
2	20	0	36	360	7	70	700	12
3	30	0	37	370	7	71	710	13
4	40	1	38	380	7	72	720	13
5	50	1	39	390	7	73	730	13
6	60	1	40	400	7	74	740	13
7	70	1	41	410	7	75	750	13
8	80	1	42	420	7	76	760	13
9	90	2	43	430	8	77	770	14
10	100	2	44	440	8	78	780	14
11	110	2	45	450	8	79	790	14
12	120	2	46	460	8	80	800	14
13	130	2	47	470	8	81	810	14
14	140	2	48	480	9	82	820	14
15	150	3	49	490	9	83	830	15
16	160	3	50	500	9	84	840	15
17	170	3	51	510	9	85	850	15
18	180	3	52	520	9	86	860	15
19	190	3	53	530	9	87	870	15
20	200	4	54	540	10	88	880	15
21	210	4	55	550	10	89	890	16
22	220	4	56	560	10	90	900	16
23	230	4	57	570	10	91	910	16
24	240	4	58	580	10	92	920	16
25	250	4	59	590	10	93	930	16
26	260	5	60	600	11	94	940	17
27	270	5	61	610	11	95	950	17
28	280	5	62	620	11	96	960	17
29	290	5	63	630	11	97	970	17
30	300	5	64	640	11	98	980	17
31	310	5	65	650	12	99	990	17
32	320	6	66	660	12	100	1000	18
33	330	6	67	670	12	200	2000	35
34	340	6	68	680	12	200	3000	53

M.	2 d.	88 d.
1	10	0
2	20	1
3	30	1
4	40	1
5	50	2
6	60	2
7	70	2
8	80	3
9	90	3
10	100	3
11	110	4
12	120	4
13	130	4
14	140	5
15	150	5
16	160	6
17	170	6
18	180	6
19	190	7
20	200	7
21	210	7
22	220	8
23	230	8
24	240	8
25	250	9
26	260	9
27	270	9
28	280	10
29	290	10
30	300	10
31	310	11
32	320	11
33	330	11
34	340	12

M.	2 d.	88 d.
35	350	12
36	360	13
37	370	13
38	380	13
39	390	14
40	400	14
41	410	14
42	420	15
43	430	15
44	440	15
45	450	16
46	460	16
47	470	16
48	480	17
49	490	17
50	500	17
51	510	18
52	520	18
53	530	18
54	540	19
55	550	19
56	560	19
57	570	20
58	580	20
59	590	20
60	600	21
61	610	21
62	620	22
63	630	22
64	640	22
65	650	23
66	662	23
67	670	23
68	680	24

Min.	2 d.	88 d.
69	690	24
70	700	24
71	710	25
72	720	25
73	730	25
74	740	26
75	750	26
76	760	26
77	770	27
78	780	27
79	790	28
80	800	28
81	809	28
82	819	29
83	829	29
84	839	29
85	849	30
86	859	30
87	869	30
88	879	31
89	889	31
90	899	31
91	909	32
92	919	32
93	929	32
94	939	33
95	949	33
96	959	34
97	969	34
98	979	34
99	989	35
100	999	35
200	1999	70
300	2998	105

M.	3 d.	87 d.
1	10	1
2	20	1
3	30	1
4	40	2
5	50	2
6	60	3
7	70	4
8	80	4
9	90	5
10	100	5
11	110	6
12	120	6
13	130	7
14	140	7
15	150	8
16	160	8
17	170	9
18	180	9
19	190	10
20	200	10
21	210	11
22	220	11
23	230	12
24	240	12
25	250	13
26	260	13
27	270	14
28	280	15
29	290	15
30	300	16
31	310	16
32	320	17
33	330	17
34	340	18
35	350	18
36	360	19
37	370	19
38	380	20
39	390	20
40	400	21
41	410	21
42	420	22
43	430	22
44	440	23
45	450	23
46	460	24
47	470	24
48	480	25
49	490	26
50	500	26
51	509	27
52	519	27
53	529	28
54	539	28
55	549	29
56	559	29
57	569	30
58	579	30
59	589	31
60	599	31
61	609	32
62	619	32
63	629	33
64	639	33
65	649	34
66	659	35
67	669	35
68	679	36

Min.	3 d.	87 d.
69	689	36
70	699	73
71	709	73
72	719	38
73	729	38
74	739	39
75	749	39
76	759	40
77	769	40
78	779	41
79	789	41
80	799	42
81	809	42
82	819	43
83	829	43
84	839	44
85	849	44
86	859	45
87	869	45
88	879	46
89	889	46
90	899	47
91	909	48
92	919	48
93	929	49
94	939	49
95	949	50
96	959	50
97	969	51
98	979	51
99	989	52
100	999	52
200	1997	105
300	2996	157

M.	4 d.	86 d.
1	10	1
2	20	1
3	30	2
4	40	3
5	50	3
6	60	4
7	70	5
8	80	6
9	90	6
10	100	7
11	110	8
12	120	8
13	130	9
14	140	10
15	150	10
16	160	11
17	170	12
18	180	13
19	190	13
20	200	14
21	209	15
22	219	15
23	229	16
24	239	17
25	249	17
26	259	18
27	269	19
28	279	20
29	289	20
30	299	21
31	309	22
32	319	22
33	329	23
34	339	24

M.	4 d.	86 d.
35	349	25
36	359	25
37	369	26
38	379	27
39	389	27
40	399	28
41	409	29
42	419	29
43	429	30
44	439	31
45	449	31
46	459	32
47	469	33
48	479	34
49	489	34
50	499	35
51	509	36
52	519	36
53	529	37
54	539	38
55	549	38
56	559	39
57	569	40
58	579	40
59	589	41
60	599	42
61	609	43
62	619	43
63	629	44
64	639	45
65	648	45
66	658	46
67	668	47
68	678	48

Min.	4 d.	86 d.
69	688	48
70	698	49
71	708	50
72	718	50
73	728	51
74	738	52
75	748	52
76	758	53
77	768	54
78	778	55
79	788	55
80	798	56
81	808	57
82	818	57
83	828	58
84	838	59
85	848	59
86	858	60
87	868	61
88	878	61
89	888	62
90	898	63
91	908	63
92	918	64
93	928	65
94	938	66
95	948	66
96	958	67
97	968	68
98	978	68
99	988	69
100	998	70
200	1905	140
300	2993	209

M.	5 d.	85 d.	M.	5 d.	85 d.	Min.	5 d.	85 d.
1	10	1	35	349	30	69	687	60
2	20	2	36	359	31	70	697	61
3	30	3	37	369	32	71	707	62
4	40	3	38	379	33	72	717	63
5	50	4	39	388	34	73	727	64
6	60	5	40	398	35	74	737	65
7	70	6	41	408	36	75	747	65
8	80	7	22	418	37	76	757	66
9	90	8	43	428	37	77	767	67
10	100	9	44	438	38	78	777	68
11	100	10	45	448	39	79	787	69
12	120	10	46	458	40	80	797	70
13	130	11	47	468	41	81	807	71
14	140	12	48	478	42	82	817	71
15	150	13	49	488	43	83	827	72
16	159	14	50	498	44	84	837	73
17	169	15	51	508	45	85	847	74
18	179	16	52	518	45	86	857	75
19	189	17	53	528	46	87	867	76
20	199	17	54	538	47	88	877	77
21	209	18	55	548	48	89	887	78
22	219	19	56	558	49	90	897	78
23	229	20	57	568	50	91	907	79
24	239	21	58	578	51	92	916	80
25	249	22	59	588	52	93	926	81
26	259	23	60	598	52	94	936	82
27	269	24	61	608	53	95	946	83
28	279	24	62	618	54	96	956	84
29	289	25	63	628	55	97	966	84
30	299	26	64	638	56	88	976	85
31	309	27	65	648	57	99	986	86
32	319	28	66	658	58	100	996	87
33	329	29	67	668	58	200	1992	174
34	339	30	68	677	59	300	2989	262

M.	6 d.	84 d.	M.	6 d.	84 d.	Min.	6 d.	84 d.
1	10	1	35	348	36	69	686	72
2	20	2	36	358	38	70	696	73
3	30	3	37	368	39	71	706	74
4	40	4	38	378	40	72	716	75
5	50	5	39	388	41	73	726	76
6	60	6	40	398	42	74	736	77
7	70	7	41	408	43	75	746	78
8	80	8	42	418	44	76	756	79
9	89	9	43	428	45	77	766	80
10	99	10	44	438	46	78	776	81
11	109	11	45	447	47	79	786	82
12	119	12	46	457	48	80	796	83
13	129	14	47	467	49	81	806	85
14	139	15	48	477	50	82	815	86
15	149	16	49	487	51	83	825	87
16	159	17	50	497	52	84	835	88
17	169	18	51	507	53	85	845	89
18	179	19	52	517	54	86	855	90
19	189	20	53	527	55	87	865	91
20	199	21	54	537	56	88	875	92
21	209	22	55	547	57	89	885	93
22	219	23	56	557	58	90	895	94
23	229	24	57	567	59	91	905	95
24	239	25	58	577	61	92	915	96
25	249	26	59	587	62	93	925	97
26	259	27	60	597	63	94	935	98
27	269	28	61	607	64	95	945	99
28	278	29	62	617	65	96	955	100
29	288	30	63	627	66	97	965	101
30	298	31	64	637	67	98	975	102
31	308	32	65	646	68	99	985	103
32	318	33	66	656	69	100	995	104
33	328	34	67	666	70	200	1980	209
34	338	35	68	676	71	300	2983	313

M.	7 d.	83 d.
1	10	1
2	20	2
3	30	4
4	40	5
5	50	6
6	60	7
7	69	8
8	79	10
9	89	11
10	99	12
11	109	13
12	119	15
13	129	16
14	139	17
15	149	18
16	159	20
17	169	21
18	179	22
19	189	23
20	199	24
21	208	26
22	218	27
23	228	28
24	238	29
25	248	30
26	258	32
27	268	33
28	278	34
29	288	35
30	298	37
31	308	38
32	318	39
33	327	40
34	337	41

M.	7 d.	83 d.
35	347	43
36	357	44
37	367	45
38	377	46
39	387	48
40	397	49
41	407	50
42	417	51
43	427	52
44	437	54
45	447	55
46	456	56
47	466	57
48	476	59
49	486	60
50	496	61
51	506	62
52	516	63
53	526	65
54	536	66
55	546	67
56	556	68
57	566	69
58	576	71
59	586	72
60	696	73
61	605	74
62	615	76
63	625	77
64	635	78
65	645	79
66	655	81
67	665	82
68	675	83

Min.	7 d.	83 d.
69	685	84
70	695	85
71	705	87
72	715	88
73	725	89
74	734	90
75	744	92
76	754	93
77	764	94
78	774	95
79	784	96
80	794	98
81	804	99
82	814	100
83	824	101
84	834	103
85	844	104
86	854	105
87	863	106
88	873	107
89	883	109
90	893	110
91	903	111
92	913	112
93	923	113
94	933	115
95	943	116
96	953	117
97	963	118
98	973	120
99	983	121
100	993	122
200	1885	244
300	2977	366

M.	8 d.	82 d.
1	10	1
2	20	3
3	30	4
4	40	6
5	50	7
6	59	8
7	69	10
8	79	11
9	89	13
10	99	14
11	109	15
12	119	17
13	129	18
14	139	19
15	148	21
16	158	22
17	168	24
18	178	25
19	188	26
20	198	28
21	208	29
22	218	31
23	228	32
24	238	33
25	248	35
26	257	36
27	267	38
28	277	39
29	287	40
30	297	42
31	307	43
32	317	44
33	327	46
34	337	47
35	347	49
36	357	50
37	366	51
38	376	53
39	386	54
40	396	56
41	406	57
42	416	58
43	426	60
44	436	61
45	446	63
46	456	64
47	466	65
48	475	67
49	485	68
50	495	70
51	505	71
52	515	72
53	525	74
54	535	75
55	545	77
56	555	78
57	565	79
58	574	81
59	584	82
60	594	83
61	604	85
62	614	86
63	624	88
64	634	89
65	644	90
66	654	92
67	664	93
68	674	95

Min.	8 d.	82 d.
69	683	90
70	693	97
71	703	99
72	713	100
73	723	102
74	733	103
75	743	104
76	753	106
77	763	107
78	772	109
79	782	110
80	792	111
81	802	113
82	812	114
83	822	115
84	832	117
85	842	118
86	852	120
87	862	121
88	872	122
89	881	124
90	891	125
91	901	127
92	911	128
93	921	129
94	931	131
95	941	132
96	951	134
97	961	135
98	970	136
99	980	138
100	990	139
200	1981	278
300	2971	418

M.	9 d.	81 d.	M.	9 d.	81 d.	Min.	9 d.	81 d.
1	10	2	35	346	55	69	682	108
2	20	3	36	356	56	70	691	109
3	30	5	37	366	58	71	701	111
4	40	6	38	375	59	72	711	112
5	50	8	39	385	61	73	721	114
6	59	9	40	395	63	74	731	116
7	69	11	41	405	64	75	741	117
8	79	13	42	415	66	76	751	119
9	89	14	43	425	67	77	761	120
10	99	15	44	435	69	78	770	122
11	109	17	45	445	71	79	780	124
12	119	19	46	454	72	80	790	125
13	129	20	47	464	73	81	800	127
14	139	22	48	474	75	82	810	128
15	148	23	49	484	77	83	820	130
16	158	25	50	494	78	84	830	131
17	168	26	51	504	80	85	840	133
18	178	28	52	514	81	86	850	134
19	188	30	53	524	83	87	859	136
20	198	31	54	534	84	88	869	138
21	208	33	55	543	86	89	879	139
22	217	34	56	553	88	90	889	141
23	227	36	57	563	89	91	899	142
24	237	37	58	573	91	92	909	144
25	247	39	59	583	92	93	919	145
26	257	41	60	593	94	94	929	147
27	267	42	61	603	95	95	938	148
28	277	44	62	612	97	96	948	150
29	287	45	63	622	98	97	958	152
30	296	47	64	632	100	98	968	153
31	306	48	65	642	102	99	970	155
32	316	50	66	652	103	100	988	156
33	326	51	67	662	105	200	1975	213
34	336	53	68	672	106	300	2963	369

M.	10d.	80d.
1	10	2
2	20	3
3	30	5
4	39	7
5	49	9
6	59	10
7	69	12
8	79	14
9	89	16
10	99	17
11	108	19
12	118	21
13	128	23
14	138	24
15	148	26
16	158	28
17	168	30
18	177	31
19	187	33
20	197	35
21	207	36
22	217	38
23	227	40
24	236	42
25	246	43
26	256	45
27	266	47
28	276	49
29	286	50
30	296	52
31	305	54
32	315	55
33	325	57
34	333	59

M.	10d.	80d.
35	345	61
36	355	62
37	365	74
38	374	76
39	384	78
40	394	79
41	404	71
42	414	73
43	424	75
44	433	76
45	443	78
46	453	80
47	463	81
48	473	83
49	483	85
50	492	87
51	502	88
52	512	90
53	522	92
54	532	94
55	542	95
56	552	97
57	551	99
58	561	101
59	571	102
60	581	104
61	591	106
62	610	108
63	620	119
64	630	111
65	640	113
66	650	115
67	660	116
68	670	118

Min.	10 d.	80 d.
69	680	120
70	689	121
71	699	123
72	709	125
73	719	127
74	729	128
75	739	130
76	749	132
77	758	133
78	768	135
79	778	137
80	788	139
81	798	141
82	808	142
83	817	144
84	827	146
85	837	148
86	847	149
87	857	151
88	867	153
89	876	154
90	886	156
91	896	158
92	906	160
93	916	161
94	925	163
95	936	165
96	946	167
97	955	168
98	965	170
99	975	172
100	985	174
200	1970	347
300	2954	521

M.	11 d.	79 d.	M.	11 d.	79 d.	Min.	11 d.	79 d.
1	10	2	35	343	67	69	677	132
2	20	4	36	353	69	70	687	134
3	29	6	37	363	71	71	697	135
4	39	8	38	373	72	72	707	137
5	49	9	39	383	74	73	716	139
6	59	11	40	393	76	74	726	141
7	69	13	41	402	78	75	736	143
8	78	15	42	412	80	76	746	145
9	88	17	43	422	82	77	756	147
10	98	19	44	432	84	78	765	149
11	108	21	45	442	86	79	775	151
12	118	23	46	452	88	80	785	153
13	128	25	47	461	90	81	795	154
14	137	27	48	471	92	82	805	156
15	147	29	49	481	93	83	815	158
16	157	30	50	491	95	84	824	160
17	167	32	51	501	97	85	834	165
18	177	34	52	510	99	86	844	164
19	186	36	53	520	101	87	854	166
20	196	38	54	530	103	88	864	168
21	206	40	55	540	105	89	873	170
22	216	42	56	550	107	90	883	172
23	226	44	57	559	109	91	893	174
24	236	46	58	569	111	92	903	176
25	245	48	59	579	112	93	913	177
26	255	50	60	589	114	94	923	179
27	265	51	61	599	116	95	932	181
28	275	53	62	609	118	96	942	183
29	285	55	63	618	120	97	952	185
30	294	57	64	628	122	98	962	187
31	304	59	65	638	124	99	972	189
32	314	61	66	648	126	100	981	191
33	324	63	67	658	128	200	1963	382
34	334	65	68	668	130	300	2944	572

M.	12d.	7 8d.
1	10	2
2	20	4
3	29	6
4	39	8
5	49	10
6	59	12
7	69	15
8	78	17
9	88	19
10	98	21
11	108	23
12	117	25
13	127	27
14	137	29
15	147	31
16	157	33
17	167	36
18	176	38
19	186	40
20	296	42
21	205	44
22	215	46
23	225	48
24	235	50
25	245	52
26	254	54
27	264	56
28	274	58
29	284	60
30	393	62
31	303	64
32	313	66
33	323	69
34	343	71

M.	12d.	7 8d.
35	342	73
36	352	75
37	362	77
38	372	79
39	381	81
40	391	83
41	401	85
22	411	87
43	420	90
44	430	92
45	440	94
46	450	96
47	460	98
48	470	100
49	479	102
50	489	104
51	499	106
52	509	108
53	518	110
54	528	112
55	538	114
56	548	116
57	558	118
58	567	121
59	577	123
60	587	125
61	597	127
62	607	129
63	616	131
64	626	133
65	636	135
66	646	137
67	655	140
68	665	142

Min.	12 d.	7 8d.
69	675	144
70	685	146
71	694	148
72	704	150
73	714	152
74	724	154
75	734	156
76	744	158
77	753	160
78	763	162
79	773	164
80	783	166
81	792	168
82	802	170
83	812	173
84	822	175
85	831	177
86	841	179
87	851	181
88	861	183
89	871	185
90	880	187
91	890	189
92	900	191
93	910	193
94	920	195
95	929	197
96	939	200
97	949	202
88	959	204
99	968	206
100	978	208
200	1956	416
300	2934	624

1	10	2
2	20	4
3	29	7
4	39	9
5	49	11
6	59	13
7	68	16
8	78	18
9	88	20
10	98	22
11	107	25
12	117	27
13	127	29
14	136	31
15	146	34
16	156	36
17	166	38
18	176	40
19	185	43
20	195	45
21	205	47
22	215	49
23	224	52
24	234	54
25	244	56
26	254	58
27	263	61
28	273	63
29	283	65
30	292	67
31	302	70
32	312	72
33	322	74
34	331	76

M.	13d.	77d.
35	341	79
36	351	81
37	361	83
38	370	86
39	380	88
40	390	90
41	400	92
22	409	94
43	419	97
44	429	99
45	438	101
46	448	103
47	458	106
48	468	108
49	478	110
50	477	112
51	497	115
52	507	117
53	516	119
54	526	121
55	536	124
56	546	126
57	555	128
58	565	130
59	575	133
60	585	135
61	594	137
62	604	140
63	614	142
64	624	144
65	634	146
66	643	148
67	653	151
68	663	153

Min.	13d.	77d.
69	672	155
70	682	157
71	692	160
72	702	162
73	711	164
74	721	166
75	731	169
76	741	171
77	750	173
78	760	175
79	770	178
80	780	180
81	789	182
82	799	184
83	809	187
84	818	189
85	828	191
86	838	193
87	848	196
88	857	198
89	867	200
90	877	202
91	887	205
92	896	207
93	906	209
94	916	211
95	926	214
96	935	216
97	945	218
88	955	221
99	965	223
100	974	225
200	1949	450
300	2923	675

M.	144d.	76d.	M.	144d.	76d.	Min.	144 d.	76 d.
1	10	2	35	340	85	69	669	167
2	19	5	36	349	87	70	679	169
3	29	7	37	359	90	71	689	172
4	39	10	38	369	92	72	698	174
5	48	12	39	378	94	73	708	177
6	58	14	40	388	97	74	718	179
7	68	17	41	398	99	75	728	182
8	78	19	42	407	102	76	737	184
9	87	22	43	417	104	77	747	187
10	97	24	44	427	107	78	757	189
11	107	27	45	437	109	79	766	191
12	116	29	46	446	111	80	776	194
13	126	31	47	456	114	81	786	195
14	136	34	48	466	116	82	796	197
15	146	36	49	475	119	83	805	200
16	155	39	50	485	121	84	815	202
17	165	41	51	495	123	85	825	205
18	175	44	52	504	126	86	834	207
19	184	46	53	514	128	87	844	209
20	194	48	54	524	131	88	854	213
21	204	51	55	534	133	89	864	215
22	213	53	56	543	136	90	873	218
23	223	56	57	553	138	91	883	220
24	233	58	58	563	140	92	893	223
25	242	60	59	572	143	93	902	225
26	252	63	60	582	145	94	912	227
27	262	65	61	592	148	95	921	230
28	272	68	62	601	150	96	931	232
29	281	70	63	611	153	97	941	235
30	291	73	64	621	155	88	951	237
31	301	75	65	631	157	99	960	240
32	310	77	66	640	160	100	970	242
33	320	80	67	650	162	200	1941	484
34	330	82	68	660	165	300	2911	726

M.	15 d.	75 d.	M.	15 d.	75 d.	M.	15 d.	75 d.
1	10	3	35	338	91	69	666	179
2	19	5	36	348	93	70	676	181
3	29	8	37	358	96	71	686	184
4	39	10	38	368	98	72	696	186
5	48	13	39	378	101	73	705	189
6	58	16	40	386	103	74	715	192
7	68	18	41	396	106	75	724	194
8	77	21	42	406	109	76	734	197
9	87	23	43	415	111	77	744	200
10	97	26	44	425	114	78	754	202
11	106	28	45	435	116	79	763	205
12	116	31	46	444	119	80	773	207
13	126	34	47	454	123	81	783	210
14	135	36	48	464	125	82	792	212
15	145	39	49	473	128	83	802	215
16	155	41	50	483	129	84	811	217
17	164	44	51	493	132	85	821	220
18	174	47	52	502	135	86	831	223
19	183	49	53	512	137	87	840	225
20	193	52	54	522	140	88	850	228
21	203	54	55	531	142	89	860	230
22	213	57	56	541	145	90	869	233
23	222	60	57	551	148	91	879	236
24	233	62	58	560	150	92	889	238
25	242	65	59	570	153	93	898	241
26	251	67	60	580	155	94	908	243
27	261	70	61	589	158	95	918	246
28	271	73	62	599	160	96	927	248
29	280	75	63	608	163	97	937	251
30	290	78	64	618	166	88	947	254
31	299	80	65	628	168	99	956	256
32	309	83	66	638	171	100	966	259
33	319	85	67	647	174	200	1932	518
34	328	88	68	657	176	300	2898	776

M.	16d.	74d.	M.	16d.	74d.	M.	16d.	74d.
1	10	3	35	336	97	69	663	190
2	19	6	36	346	99	70	673	193
3	29	8	37	356	102	71	682	196
4	38	11	38	365	105	72	692	199
5	48	14	39	375	107	73	702	201
6	58	17	40	384	110	74	711	204
7	67	19	41	394	113	75	721	207
8	77	22	42	404	116	76	731	210
9	86	25	43	413	119	77	740	213
10	96	28	44	423	121	78	750	215
11	106	30	45	432	124	79	759	218
12	115	33	46	442	127	80	769	220
13	125	36	47	452	130	81	779	223
14	134	39	48	461	132	82	788	226
15	144	41	49	471	135	83	798	229
16	154	44	50	481	138	84	807	232
17	163	47	51	490	141	85	817	235
18	173	50	52	500	143	86	827	237
19	183	53	53	509	146	87	836	240
20	192	55	54	519	149	88	846	243
21	202	58	55	529	151	89	856	245
22	211	61	56	538	154	90	865	248
23	222	63	57	548	157	91	975	251
24	231	66	58	557	160	92	984	254
25	240	69	59	567	163	93	994	257
26	250	72	60	577	165	94	904	259
27	259	75	61	586	168	95	913	262
28	269	77	62	596	171	96	923	265
29	279	80	63	606	174	97	932	267
30	288	83	64	615	177	98	942	270
31	298	85	65	625	179	99	952	273
32	308	88	66	634	182	100	961	276
33	317	91	67	644	185	200	1923	551
34	327	94	68	654	188	300	2884	827

M.	1 d.	7 h.	nil m.	M.	1 d.	7 h.	1 m.	M.	Min.	37 d.	73 d.
1	10	3	0	35	335	101	28	69	660	202	
2	19	6	7	36	344	105	28	70	669	205	
3	29	9	7	37	354	108	27	71	679	207	
4	38	12	7	38	363	111	28	72	688	210	
5	48	15	7	39	373	114	29	73	698	213	
6	57	17	7	40	383	117	01	74	708	216	
7	67	20	7	41	392	120	14	75	717	219	
8	76	23	7	42	402	123	24	76	727	222	
9	86	26	7	43	411	126	24	77	736	225	
10	96	29	7	44	421	129	24	78	746	228	
11	105	32	7	45	430	131	27	79	755	231	
12	115	35	8	46	440	134	01	80	765	234	
13	124	38	8	47	449	137	24	81	775	237	
14	134	41	8	48	459	140	24	82	784	240	
15	143	44	8	49	469	143	24	83	794	243	
16	153	47	8	50	478	146	24	84	803	246	
17	162	50	8	51	488	149	24	85	813	248	
18	172	52	8	52	497	152	27	86	822	251	
19	182	55	8	53	507	155	27	87	832	254	
20	191	58	8	54	516	158	27	88	842	257	
21	201	61	8	55	526	161	27	89	851	260	
22	210	64	9	56	535	164	01	90	861	263	
23	220	67	9	57	545	167	24	91	870	266	
24	230	70	9	58	554	170	24	92	880	269	
25	239	73	9	59	564	172	24	93	889	272	
26	249	76	9	60	574	175	27	94	899	276	
27	258	79	9	61	583	178	01	95	908	278	
28	268	82	9	62	593	181	24	96	918	281	
29	277	85	9	63	602	184	24	97	927	284	
30	287	88	9	64	612	187	24	98	937	287	
31	296	91	9	65	620	190	27	99	947	289	
32	306	93	10	66	631	193	01	100	956	292	
33	316	96	10	67	641	196	24	200	1913	585	
34	325	99	10	68	650	199	24	300	2869	877	

M.	18d.	72d.	M.	18d.	72d.	Min.	18d.	72d.
1	10	3	35	338	108	69	656	213
2	19	6	36	342	111	70	666	216
3	28	9	37	352	114	71	675	219
4	38	12	38	361	117	72	685	222
5	47	15	39	371	120	73	694	225
6	57	18	40	380	124	74	704	229
7	66	22	41	390	127	75	713	232
8	76	25	42	398	130	76	723	235
9	85	28	43	408	133	77	732	238
10	95	31	44	417	136	78	742	241
11	104	34	45	427	139	79	751	244
12	114	37	46	436	142	80	761	247
13	123	40	47	446	145	81	770	250
14	133	43	48	455	148	82	780	253
15	142	46	49	465	151	83	789	256
16	152	50	50	476	154	84	799	260
17	161	53	51	485	158	85	808	263
18	171	56	52	495	161	86	818	266
19	180	59	53	504	164	87	827	269
20	190	62	54	514	167	88	837	272
21	200	65	55	523	170	89	846	275
22	209	68	56	533	173	90	856	278
23	219	71	57	542	176	91	865	281
24	228	74	58	552	179	92	875	284
25	238	77	59	561	182	93	884	287
26	247	81	60	571	185	94	894	290
27	257	84	61	580	188	95	903	293
28	266	87	62	598	192	96	913	297
29	276	90	63	599	195	97	922	300
30	285	93	64	609	198	98	932	303
31	295	96	65	618	201	99	941	306
32	304	99	66	628	204	100	951	309
33	314	102	67	637	207	200	1902	618
34	323	105	68	647	210	300	2850	927

M.	19 d.	71 d.
1	9	3
2	19	6
3	28	10
4	38	13
5	47	16
6	57	20
7	66	23
8	75	26
9	85	29
10	94	33
11	104	36
12	113	39
13	123	42
14	132	46
15	142	49
16	151	52
17	161	55
18	170	59
19	180	62
20	189	65
21	199	68
22	208	72
23	217	75
24	227	78
25	236	82
26	246	85
27	255	88
28	265	91
29	274	94
30	284	98
31	293	101
32	303	104
33	312	107
34	321	111
35	331	114
36	340	117
37	350	121
38	359	124
39	369	127
40	378	130
41	388	134
42	397	137
43	407	140
44	416	143
45	425	147
46	435	150
47	444	153
48	454	156
49	463	160
50	473	163
51	482	166
52	492	169
53	501	173
54	510	176
55	520	179
56	539	182
57	549	186
58	558	189
59	567	192
60	577	195
61	586	199
62	596	202
63	605	205
64	615	208
65	624	212
66	634	215
67	644	218
68	653	222

Min.	19 d.	71 d.
69	652	225
70	662	228
71	671	231
72	681	234
73	690	238
74	699	241
75	709	244
76	718	247
77	728	251
78	737	254
79	747	257
80	756	261
81	766	264
82	775	267
83	785	270
84	794	274
85	804	277
86	813	280
87	822	283
88	832	287
89	841	290
90	851	293
91	860	296
92	870	300
93	879	303
94	889	306
95	898	309
96	908	313
97	917	316
98	926	319
99	936	322
100	945	326
200	1891	651
300	2836	977

M.	20 d.	70 d.
1	9	3
2	19	7
3	28	10
4	38	14
5	47	17
6	56	20
7	66	24
8	75	27
9	85	31
10	94	34
11	103	38
12	113	41
13	122	44
14	132	48
15	141	51
16	150	55
17	160	58
18	169	61
19	179	65
20	188	68
21	197	72
22	207	75
23	216	79
24	226	82
25	235	85
26	244	89
27	254	92
28	263	96
29	272	100
30	282	103
31	291	106
32	301	109
33	310	113
34	319	116

M.	20 d.	70 d.
35	329	120
36	338	123
37	348	126
38	357	130
39	366	133
40	376	137
41	385	140
42	395	144
43	404	147
44	413	150
45	423	154
46	432	157
47	442	161
48	451	164
49	460	168
50	470	171
51	479	174
52	489	178
53	498	181
54	507	185
55	517	188
56	526	191
57	536	195
58	545	198
59	554	202
60	564	205
61	573	209
62	583	212
63	592	215
64	601	219
65	611	222
66	620	226
67	630	229
68	639	233

Min.	20 d.	70 d.
69	648	236
70	658	239
71	667	243
72	677	246
73	686	250
74	695	253
75	705	256
76	714	260
77	724	263
78	733	267
79	742	270
80	752	274
81	761	277
82	771	280
83	780	284
84	789	287
85	800	291
86	808	294
87	818	298
88	827	301
89	836	304
90	846	308
91	855	311
92	864	315
93	874	318
94	883	321
95	893	325
96	902	328
97	911	332
98	921	335
99	930	339
100	940	342
200	1879	684
300	2819	1026

M.	21d.	69d.	M.	21d.	69d.	Min.	21 d.	69 d.
1	9	4	35	327	125	69	644	247
2	19	7	36	336	129	70	653	251
3	28	11	37	345	132	71	663	254
4	37	14	38	355	136	72	672	258
5	47	18	39	364	140	73	681	262
6	56	21	40	373	143	74	691	265
7	65	25	41	383	147	75	700	269
8	75	29	42	392	150	76	709	272
9	84	32	43	401	154	77	719	276
10	93	36	44	411	158	78	728	279
11	103	39	45	420	161	79	737	283
12	112	43	46	429	165	80	747	287
13	121	47	47	439	168	81	756	290
14	131	50	48	448	172	82	766	294
15	140	54	49	457	176	83	775	297
16	149	57	50	467	179	84	784	301
17	159	61	51	476	183	85	794	305
18	168	64	52	485	186	86	803	308
19	177	68	53	495	190	87	812	312
20	187	72	54	504	193	88	822	315
21	196	75	55	513	197	89	831	319
22	205	79	56	523	201	90	840	323
23	215	82	57	532	204	91	849	326
24	224	86	58	541	208	92	859	330
25	233	90	59	551	211	93	868	333
26	243	93	60	560	215	94	877	337
27	252	97	61	569	219	95	887	340
28	261	100	62	579	222	96	896	344
29	271	104	63	588	226	97	905	348
30	280	107	64	698	229	98	915	351
31	289	111	65	607	233	99	924	355
32	299	115	66	616	236	100	934	358
33	308	118	67	626	240	200	1867	717
34	317	122	68	635	244	300	1801	1075

M.	22d.	68d.
1	9	4
2	19	7
3	28	11
4	37	15
5	46	19
6	56	22
7	65	26
8	74	30
9	83	34
10	93	37
11	102	41
12	111	45
13	120	49
14	130	52
15	139	56
16	148	60
17	157	64
18	167	67
19	176	71
20	185	75
21	195	79
22	204	82
23	213	86
24	222	90
25	232	94
26	241	97
27	250	101
28	260	105
29	269	109
30	278	112
31	287	116
32	297	120
33	306	124
34	315	127

M.	22d.	68d.
35	324	131
36	334	135
37	343	139
38	352	142
39	361	146
40	371	150
41	380	154
42	389	157
43	399	161
44	408	165
45	416	169
46	426	172
47	437	176
48	445	180
49	454	184
50	464	187
51	473	191
52	482	195
53	491	199
54	501	202
55	510	206
56	519	210
57	529	214
58	538	217
59	547	221
60	556	225
61	566	229
62	575	232
63	584	236
64	594	240
65	603	244
66	612	247
67	621	251
68	631	255

Min.	22 d.	68 d.
69	640	259
70	649	262
71	658	266
72	667	270
73	677	274
74	686	277
75	695	281
76	705	285
77	714	289
78	723	292
79	733	296
80	742	300
81	751	304
82	760	307
83	770	311
84	779	315
85	788	319
86	797	322
87	806	326
88	816	330
89	825	334
90	834	337
91	844	341
92	853	345
93	862	349
94	871	352
95	881	356
96	890	360
97	899	364
98	909	367
99	918	371
100	927	375
200	1854	749
300	2782	1094

M.	23 d.	67 d.	M.	23 d.	67 d.	Min.	23 d.	67 d.
1	9	4	35	322	137	69	635	269
2	18	8	36	331	141	70	644	273
3	28	12	37	340	144	71	653	277
4	37	16	38	350	148	72	663	281
5	46	19	39	359	152	73	672	285
6	55	23	40	368	156	74	681	289
7	64	27	41	377	160	75	690	293
8	74	31	42	386	164	76	699	297
9	83	35	43	396	168	77	709	304
10	92	39	44	405	172	78	718	303
11	101	43	45	414	176	79	727	308
12	110	47	46	423	180	80	736	312
13	120	51	47	433	184	81	746	316
14	129	55	48	442	187	82	755	320
15	138	59	49	451	191	83	764	324
16	147	62	50	460	195	84	773	328
17	156	66	51	469	199	85	782	332
18	166	70	52	479	203	86	792	336
19	175	74	53	488	207	87	801	340
20	184	78	54	497	211	88	810	344
21	193	82	55	506	215	89	819	348
22	202	86	56	515	219	90	828	352
23	212	90	57	524	223	91	838	356
24	221	94	58	534	226	92	847	360
25	230	98	59	543	230	93	856	363
26	239	102	60	552	234	94	865	367
27	248	105	61	561	238	95	874	370
28	258	109	62	571	242	96	884	375
29	267	113	63	580	246	97	893	379
30	276	117	64	589	250	98	902	383
31	285	121	65	598	254	99	911	387
32	294	125	66	608	258	100	920	390
33	304	129	67	618	262	200	1841	781
34	313	133	68	628	266	300	2761	1172

M.	24d.	66d.	M.	24d.	66d.	Min.	24d.	66d.
1	9	4	35	320	142	69	630	281
2	18	8	36	329	146	70	639	285
3	27	12	37	338	151	71	648	289
4	36	16	38	347	155	72	658	293
5	46	20	39	356	159	73	667	297
6	55	24	40	365	163	74	676	301
7	64	28	41	374	167	75	685	305
8	73	32	42	384	171	76	694	309
9	82	37	43	393	175	77	703	313
10	91	41	44	402	179	78	712	317
11	100	45	45	411	183	79	721	321
12	109	49	46	420	187	80	731	325
13	119	53	47	429	191	81	740	329
14	128	57	48	438	195	82	749	333
15	137	61	49	448	199	83	758	337
16	146	65	50	457	203	84	767	341
17	155	69	51	466	207	85	776	345
18	164	73	52	475	211	86	785	349
19	173	77	53	484	216	87	795	353
20	183	81	54	493	220	88	804	357
21	192	85	55	502	224	89	813	362
22	201	90	56	511	228	90	822	366
23	210	94	57	521	232	91	831	370
24	219	98	58	530	236	92	840	374
25	228	102	59	539	240	93	849	378
26	237	106	60	548	244	94	858	382
27	246	110	61	557	248	95	868	386
28	256	113	62	566	252	96	877	390
29	265	117	63	575	256	97	886	395
30	274	122	64	585	260	98	895	399
31	283	126	65	594	264	99	904	403
32	292	130	66	603	268	100	913	407
33	301	134	67	612	272	200	1827	813
34	310	138	68	621	276	300	2740	1220

M.	25 d.	65 d.
1	9	4
2	18	8
3	27	13
4	36	17
5	45	21
6	54	25
7	63	30
8	72	34
9	81	38
10	91	42
11	100	47
12	109	51
13	118	55
14	127	59
15	136	63
16	145	68
17	154	72
18	163	76
19	172	80
20	181	84
21	190	89
22	199	93
23	208	97
24	218	101
25	227	106
26	236	110
27	245	114
28	254	118
29	263	123
30	272	127
31	281	131
32	290	135
33	299	140
34	308	144
35	317	148
36	326	152
37	335	156
38	344	161
39	353	165
40	362	169
41	372	173
42	381	178
43	390	182
44	399	186
45	408	190
46	417	195
47	426	199
48	435	203
49	444	207
50	453	211
51	462	216
52	471	220
53	480	224
54	489	228
55	498	232
56	507	237
57	516	241
58	526	245
59	535	250
60	544	254
61	553	258
62	562	262
63	571	267
64	580	271
65	589	275
66	598	279
67	607	283
68	616	288

Min.	25 d.	65 d.
69	625	292
70	634	296
71	643	300
72	652	305
73	662	309
74	671	313
75	680	317
76	689	321
77	698	326
78	707	330
79	716	334
80	725	338
81	734	343
82	743	347
83	752	351
84	761	355
85	770	360
86	779	364
87	788	368
88	797	372
89	807	376
90	816	380
91	825	384
92	834	389
93	843	393
94	852	397
95	861	401
96	870	406
97	879	410
98	888	414
99	897	418
100	906	423
200	1813	845
300	2719	1268

M.	26d.	64d.	M.	26d.	64d.	Min.	26d.	64d.
1	9	4	35	315	153	69	620	302
2	18	9	36	324	158	70	629	307
3	27	13	37	333	162	71	638	311
4	36	18	38	342	166	72	647	316
5	46	22	39	351	171	73	656	320
6	54	26	40	360	175	74	665	324
7	63	31	41	368	179	75	674	329
8	72	35	42	378	184	76	683	333
9	81	39	43	386	188	77	692	338
10	90	44	44	395	193	78	701	342
11	99	48	45	404	197	79	710	346
12	108	53	46	413	202	80	719	351
13	117	57	47	422	206	81	728	355
14	126	61	48	431	210	82	737	359
15	135	66	49	440	214	83	746	364
16	144	70	50	449	219	84	755	368
17	153	74	51	458	223	85	764	372
18	162	79	52	467	228	86	773	377
19	171	83	53	476	232	87	782	381
20	180	88	54	485	237	88	791	385
21	189	92	55	494	241	89	800	390
22	198	96	56	503	245	90	809	394
23	207	101	57	512	250	91	818	399
24	216	105	58	521	254	92	827	403
25	225	109	59	530	258	93	836	407
26	234	114	60	539	263	94	845	412
27	243	118	61	548	267	95	854	416
28	252	123	62	557	272	96	863	421
29	261	127	63	566	276	97	872	425
30	270	131	64	575	280	98	881	429
31	279	136	65	584	285	99	890	434
32	288	140	66	593	289	100	899	438
33	297	144	67	602	294	200	1798	877
34	306	149	68	611	298	300	2696	1315

M.	27 d.	63 d.	M.	27 d.	63 d.	M.	Min.	27 d.	63 d.
1	9	5	35	312	159	66	69	615	313
2	18	9	36	321	163	67	70	624	318
3	27	14	37	330	168	68	71	633	322
4	36	18	38	338	172	69	72	641	327
5	45	23	39	347	177	70	73	650	332
6	53	27	40	356	181	71	74	659	336
7	62	32	41	365	186	72	75	668	341
8	71	36	42	374	191	73	76	677	345
9	80	41	43	383	195	74	77	686	350
10	89	45	44	391	200	75	78	695	354
11	98	50	45	401	204	76	79	704	359
12	107	54	46	410	209	77	80	713	363
13	116	59	47	419	213	78	81	722	368
14	125	63	48	428	218	79	82	731	372
15	134	68	49	436	222	80	83	739	377
16	143	72	50	445	227	81	84	748	381
17	151	77	51	454	232	82	85	757	386
18	160	82	52	463	236	83	86	766	390
19	169	86	53	472	241	84	87	775	395
20	178	91	54	481	245	85	88	784	400
21	187	95	55	490	250	86	89	793	404
22	196	100	56	498	254	87	90	802	409
23	205	104	57	508	259	88	91	811	413
24	214	109	58	517	263	89	92	820	418
25	223	113	59	526	268	90	93	829	422
26	232	118	60	535	272	91	94	837	427
27	241	122	61	543	277	92	95	846	431
28	249	127	62	552	282	93	96	855	436
29	258	132	63	561	286	94	97	864	440
30	267	136	64	570	291	95	98	873	445
31	276	141	65	579	295	96	99	882	449
32	285	145	66	588	300	97	100	891	454
33	294	150	67	597	304	98	200	1781	909
34	303	154	68	606	309	99	300	2673	1363

M.	28d.	62d.	M.	28d.	62d.	Min.	28d.	62d.
1	9	5	35	309	164	69	609	323
2	18	9	36	318	169	70	618	329
3	26	14	37	326	174	71	626	333
4	35	19	38	335	178	72	636	338
5	44	23	39	344	183	73	644	343
6	53	28	40	353	188	74	653	347
7	62	33	41	362	192	75	662	352
8	71	37	42	371	197	76	671	357
9	79	42	43	380	202	77	680	362
10	88	47	44	388	207	78	689	366
11	97	52	45	397	211	79	697	371
12	106	56	46	406	216	80	706	376
13	115	61	47	415	221	81	715	380
14	124	66	48	424	225	82	724	385
15	132	70	49	432	230	83	733	390
16	141	75	50	441	235	84	742	394
17	150	80	51	450	239	85	750	399
18	159	84	52	459	244	86	759	404
19	168	89	53	468	249	87	768	408
20	177	94	54	477	254	88	777	413
21	185	99	55	485	258	89	786	418
22	194	103	56	494	263	90	795	422
23	203	108	57	503	268	91	803	427
24	211	113	58	512	272	92	812	432
25	221	117	59	521	277	93	821	437
26	230	122	60	530	282	94	830	441
27	238	127	61	538	286	95	839	446
28	247	131	62	547	291	96	848	451
29	256	136	63	556	296	97	856	455
30	265	141	64	565	300	98	865	460
31	274	145	65	574	305	99	874	465
32	282	150	66	583	310	100	883	469
33	291	155	67	591	315	200	1766	939
34	300	160	68	600	319	300	2649	1408

M.	29d.	61d.
1	9	5
2	17	10
3	26	14
4	35	19
5	44	24
6	52	29
7	61	34
8	70	39
9	79	43
10	87	48
11	96	53
12	105	58
13	114	63
14	122	68
15	131	73
16	140	77
17	149	82
18	157	86
19	166	92
20	175	97
21	184	102
22	192	107
23	201	111
24	210	116
25	219	121
26	227	126
27	236	131
28	245	136
29	254	141
30	262	145
31	271	150
32	280	155
33	289	160
34	297	165

M.	29d.	61d.
35	306	170
36	315	174
37	324	179
38	332	184
39	341	189
40	350	194
41	359	199
42	367	203
43	376	208
44	385	213
45	394	218
46	402	223
47	411	228
48	420	233
49	429	237
50	437	242
51	446	247
52	455	252
53	464	257
54	472	262
55	481	267
56	490	271
57	499	276
58	507	281
59	516	286
60	525	291
61	534	296
62	542	301
63	551	305
64	560	310
65	569	315
66	577	320
67	586	325
68	595	330

Min.	29d.	61d.
69	604	334
70	612	339
71	621	344
72	630	349
73	638	354
74	647	359
75	656	363
76	665	368
77	673	373
78	682	378
79	691	383
80	700	388
81	708	393
82	717	397
83	726	402
84	735	407
85	743	412
86	752	417
87	761	422
88	770	427
89	778	431
90	787	436
91	796	441
92	805	446
93	813	451
94	822	456
95	831	461
96	840	465
97	848	470
98	857	475
99	866	480
100	875	485
200	1749	970
300	2624	1454

M.	30d.	60d.	M.	30d.	60d.	Min.	30d.	60d.
1	9	5	35	303	175	69	598	345
2	17	10	36	312	180	70	606	350
3	26	15	37	320	185	71	615	355
4	35	20	38	329	190	72	623	360
5	43	25	39	338	195	73	632	365
6	52	30	40	346	200	74	641	370
7	61	35	41	355	205	75	649	375
8	69	40	42	364	210	76	658	380
9	78	45	43	372	215	77	667	385
10	87	50	44	381	220	78	676	390
11	95	55	45	390	225	79	684	395
12	104	60	46	398	230	80	693	400
13	113	65	47	407	235	81	702	405
14	121	70	48	416	240	82	710	410
15	130	75	49	424	245	83	719	415
16	139	80	50	433	250	84	727	420
17	147	85	51	442	255	85	736	425
18	156	90	52	450	260	86	745	430
19	165	95	53	459	265	87	753	435
20	173	100	54	468	270	88	762	440
21	182	105	55	476	275	89	771	445
22	191	110	56	485	280	90	779	450
23	199	115	57	494	285	91	788	455
24	208	120	58	502	290	92	797	460
25	217	125	59	511	295	93	806	465
26	225	130	60	520	300	94	814	470
27	234	135	61	528	305	95	823	475
28	242	140	62	537	310	96	832	480
29	251	145	63	546	315	97	840	485
30	260	150	64	554	320	98	849	490
31	268	155	65	563	325	99	857	495
32	277	160	66	572	330	100	866	520
33	286	165	67	580	335	200	1732	1000
34	294	170	68	589	340	300	2598	1500

M.	5 d.	7 d.
1	9	5
2	17	10
3	26	15
4	34	21
5	43	26
6	51	31
7	60	36
8	69	41
9	77	46
10	86	51
11	94	57
12	103	62
13	111	67
14	120	72
15	129	77
16	137	82
17	146	88
18	154	93
19	163	98
20	171	103
21	180	108
22	189	113
23	197	118
24	206	124
25	214	129
26	223	134
27	231	139
28	240	144
29	249	149
30	257	154
31	266	160
32	274	165
33	283	170
34	292	175

M.	31 d.	99 d.
35	300	180
36	309	185
37	317	191
38	326	196
39	334	201
40	343	206
41	351	211
42	360	216
43	369	221
44	377	227
45	386	232
46	394	237
47	403	242
48	411	247
49	420	252
50	429	257
51	437	263
52	446	268
53	454	273
54	463	278
55	471	283
56	480	288
57	489	294
58	497	299
59	506	304
60	514	309
61	523	314
62	531	319
63	540	324
64	549	330
65	557	335
66	566	340
67	574	345
68	583	350

Min.	31 d.	59 d.
69	591	355
70	600	360
71	609	366
72	617	371
73	626	376
74	634	381
75	643	386
76	651	391
77	660	397
78	669	402
79	677	407
80	686	412
81	694	417
82	703	422
83	711	427
84	720	433
85	729	438
86	737	443
87	746	448
88	754	453
89	763	458
90	771	463
91	780	469
92	789	474
93	797	479
94	806	484
95	814	489
96	823	494
97	831	500
98	840	505
99	849	510
100	857	515
200	1714	1030
300	2572	1545

M.	32d.	58d.	M.	32d.	58d.	M.	32d.	58d.
1	8	5	35	297	185	Min.		
2	17	11	36	305	191	69	585	366
3	25	16	37	314	196	70	594	371
4	34	21	38	322	201	71	602	376
5	42	26	39	331	207	72	610	381
6	51	32	40	339	212	73	619	387
7	59	37	41	348	217	74	627	392
8	68	42	42	356	223	75	636	397
9	76	48	43	365	228	76	644	403
10	85	53	44	373	233	77	653	408
11	93	58	45	382	238	78	661	413
12	102	64	46	390	244	79	670	419
13	110	69	47	398	249	80	678	424
14	119	74	48	407	254	81	687	429
15	127	79	49	415	260	82	695	434
16	136	85	50	424	265	83	703	440
17	144	90	51	432	270	84	712	445
18	153	95	52	441	275	85	721	450
19	161	101	53	449	281	86	729	456
20	170	106	54	458	286	87	738	461
21	178	111	55	466	291	88	746	466
22	187	117	56	475	297	89	755	472
23	195	122	57	483	302	90	763	477
24	204	127	58	492	307	91	772	482
25	212	132	59	500	313	92	780	487
26	220	138	60	509	318	93	788	493
27	229	143	61	517	323	94	797	498
28	237	148	62	526	329	95	805	509
29	249	153	63	534	334	96	814	503
30	254	159	64	543	339	97	822	514
31	263	164	65	551	344	98	831	519
32	271	170	66	560	350	99	839	524
33	280	175	67	568	355	100	848	530
34	288	180	68	577	360	200	1696	1060
						300	2544	1590

M.	33d.	57d.	M.	33d.	57d.	Min.	33d.	57 d.
1	8	5	35	294	191	69	579	376
2	17	11	36	302	196	70	587	381
3	25	16	37	311	202	71	596	386
4	34	22	38	319	207	72	604	392
5	42	27	39	327	212	73	612	397
6	50	33	40	335	218	74	621	403
7	59	38	41	344	223	75	629	408
8	67	44	42	352	229	76	637	414
9	76	49	43	361	234	77	646	419
10	84	54	44	369	240	78	654	425
11	92	60	45	377	245	79	663	430
12	101	65	46	386	251	80	671	436
13	109	71	47	394	256	81	679	441
14	117	76	48	403	262	82	688	446
15	126	82	49	411	267	83	696	452
16	134	87	50	419	272	84	705	457
17	143	93	51	428	278	85	713	462
18	151	98	52	436	283	86	721	468
19	159	104	53	445	288	87	730	473
20	168	109	54	453	294	88	738	479
21	176	114	55	461	300	89	747	484
22	185	120	56	470	305	90	755	490
23	193	125	57	478	310	91	763	495
24	201	131	58	487	316	92	772	501
25	210	136	59	495	321	93	780	506
26	218	142	60	503	327	94	788	512
27	227	147	61	512	332	95	797	517
28	235	153	62	520	338	96	805	522
29	243	158	63	529	343	97	814	528
30	252	163	64	537	348	98	822	533
31	260	169	65	545	354	99	831	539
32	269	174	66	554	359	100	839	545
33	277	180	67	562	365	200	1677	1089
34	285	185	68	571	370	300	2516	1634

M.	34 d.	56 d.
1	8	6
2	17	11
3	25	17
4	33	22
5	41	28
6	50	34
7	58	39
8	66	45
9	75	50
10	83	56
11	91	61
12	99	67
13	108	73
14	116	78
15	124	84
16	133	89
17	141	95
18	149	101
19	158	106
20	166	112
21	174	117
22	182	123
23	191	129
24	199	134
25	207	140
26	216	145
27	224	151
28	232	157
29	240	162
30	249	168
31	257	173
32	265	179
33	274	184
34	282	190

M.	34 d.	56 d.
35	290	196
36	298	201
37	307	207
38	315	212
39	323	218
40	332	224
41	340	229
42	348	235
43	356	240
44	365	246
45	373	251
46	381	257
47	390	263
48	398	268
49	406	274
50	414	280
51	423	285
52	431	291
53	439	296
54	448	302
55	456	307
56	464	313
57	473	319
58	481	324
59	489	330
60	497	335
61	506	341
62	514	346
63	522	352
64	530	358
65	539	363
66	547	369
67	555	374
68	564	380

Min.	34 d.	56 d.
69	572	386
70	580	391
71	588	397
72	597	403
73	605	408
74	613	414
75	622	419
76	630	425
77	638	431
78	647	436
79	655	442
80	663	447
81	671	453
82	680	458
83	688	464
84	696	470
85	705	475
86	713	481
87	721	486
88	729	492
89	738	498
90	746	503
91	754	509
92	763	514
93	771	520
94	779	526
95	788	531
96	796	537
97	804	542
98	812	548
99	821	554
100	829	559
200	1658	1118
300	2487	1678

M.	35 d.	55 d.
1	8	6
2	17	11
3	25	17
4	33	23
5	41	29
6	49	34
7	57	40
8	66	46
9	74	52
10	82	57
11	90	63
12	98	69
13	106	75
14	115	80
15	123	86
16	131	92
17	139	98
18	147	103
19	156	109
20	164	115
21	172	120
22	180	126
23	188	132
24	196	138
25	205	143
26	213	139
27	221	155
28	229	161
29	237	166
30	246	172
31	254	178
32	262	184
33	270	189
34	278	195

M.	35 d.	55 d.
35	286	201
36	295	206
37	303	212
38	311	218
39	319	224
40	328	229
41	336	235
42	344	241
43	352	246
44	360	252
45	368	258
46	377	264
47	385	270
48	393	275
49	401	281
50	410	287
51	418	292
52	426	298
53	434	304
54	442	310
55	451	315
56	459	321
57	467	327
58	475	333
59	483	338
60	491	344
61	500	350
62	508	356
63	516	361
64	524	367
65	533	373
66	541	379
67	549	384
68	557	390

Min.	35 d.	55 d.
69	565	396
70	573	402
71	582	407
72	590	413
73	598	419
74	606	425
75	615	430
76	623	436
77	631	442
78	639	448
79	647	453
80	655	459
81	664	465
82	672	470
83	680	476
84	688	482
85	696	488
86	705	493
87	713	499
88	721	505
89	729	511
90	737	516
91	746	522
92	754	528
93	762	534
94	770	539
95	778	545
96	786	551
97	795	556
98	803	562
99	811	568
100	819	574
200	1638	1147
300	2458	1721

M.	36 d.	54 d.
1	8	6
2	16	12
3	24	18
4	32	23
5	40	29
6	48	35
7	56	41
8	64	47
9	72	53
10	81	59
11	89	65
12	97	70
13	105	76
14	113	82
15	121	88
16	129	94
17	138	100
18	146	106
19	154	112
20	162	118
21	170	123
22	178	129
23	186	135
24	194	141
25	202	147
26	210	153
27	218	159
28	226	164
29	235	170
30	243	176
31	251	182
32	259	188
33	267	194
34	274	200

M.	36 d.	54 d.
35	283	206
36	291	211
37	299	217
38	307	223
39	315	229
40	324	235
41	332	241
42	340	247
43	348	253
44	356	258
45	364	264
46	372	270
47	480	276
48	488	282
49	496	288
50	404	294
51	413	300
52	421	306
53	429	311
54	437	317
55	445	323
56	453	329
57	461	335
58	469	341
59	477	347
60	485	353
61	493	358
62	502	364
63	510	370
64	518	376
65	526	382
66	534	388
67	542	394
68	550	400

Min.	36 d.	54 d.
69	558	406
70	566	411
71	574	417
72	582	423
73	590	429
74	599	435
75	607	441
76	615	447
77	623	453
78	631	458
79	639	464
80	647	470
81	655	476
82	663	482
83	671	488
84	680	494
85	688	500
86	696	506
87	704	511
88	712	517
89	720	523
90	728	529
91	736	535
92	744	541
93	752	547
94	760	553
95	768	558
96	777	564
97	785	570
88	793	576
99	801	582
100	809	588
200	1618	1176
300	2426	1763

M.	37d.	53d.	M.	37d.	53d.	Min.	37d.	53d.
1	8	6	35	279	210	69	551	415
2	16	12	36	287	216	70	559	421
3	24	18	37	295	222	71	567	427
4	32	24	38	303	228	72	575	433
5	40	30	39	311	234	73	583	439
6	48	36	40	319	241	74	591	445
7	56	42	41	327	247	75	599	451
8	64	48	42	335	253	76	607	457
9	72	54	43	343	259	77	615	463
10	80	60	44	351	265	78	623	469
11	88	66	45	359	271	79	631	475
12	89	72	46	367	277	80	639	481
13	104	78	47	375	283	81	647	487
14	112	84	48	383	289	82	655	493
15	120	90	49	391	295	83	663	500
16	128	96	50	399	301	84	671	506
17	136	102	51	407	307	85	679	512
18	144	108	52	415	313	86	687	518
19	152	114	53	423	319	87	695	524
20	160	120	54	431	325	88	703	530
21	168	126	55	439	331	89	711	536
22	176	132	56	447	337	90	719	542
23	184	138	57	455	343	91	727	548
24	192	144	58	463	349	92	735	554
25	200	150	59	471	355	93	743	560
26	208	156	60	479	361	94	751	566
27	216	162	61	487	367	95	759	572
28	224	168	62	495	373	96	767	578
29	232	174	63	503	379	97	775	584
30	240	180	64	511	385	88	783	590
31	248	186	65	519	391	99	791	596
32	256	192	66	527	397	100	799	602
33	264	198	67	535	403	200	1597	1204
34	271	204	68	543	409	300	2396	1805

M.	38d.	52d.
1	8	6
2	16	12
3	24	18
4	31	25
5	39	31
6	47	37
7	55	43
8	63	49
9	71	55
10	79	62
11	87	68
12	95	74
13	102	80
14	110	86
15	118	92
16	126	99
17	134	105
18	142	111
19	150	117
20	158	123
21	166	129
22	173	136
23	181	142
24	189	148
25	197	154
26	205	160
27	213	166
28	221	172
29	228	179
30	236	185
31	244	191
32	252	197
33	260	203
34	268	209

M.	38d.	52d.
35	276	216
36	284	222
37	292	228
38	299	234
39	307	240
40	315	246
41	323	252
42	341	259
43	339	265
44	347	271
45	355	277
46	362	283
47	370	289
48	378	296
49	386	302
50	394	308
51	402	314
52	410	320
53	418	326
54	426	332
55	433	339
56	441	345
57	449	351
58	457	357
59	465	363
60	473	369
61	481	376
62	489	382
63	496	388
64	504	494
65	512	400
66	520	406
67	528	412
68	536	419

Min.	38d.	52d.
69	544	425
70	552	431
71	559	437
72	567	443
73	575	450
74	583	456
75	591	462
76	599	468
77	607	474
78	615	480
79	622	486
80	630	493
81	638	499
82	646	505
83	654	511
84	662	517
85	670	523
86	678	530
87	686	536
88	693	542
89	701	548
90	709	554
91	717	560
92	725	566
93	733	573
94	741	579
95	749	585
96	756	591
97	764	597
88	772	603
99	780	610
100	788	616
200	1576	1231
300	2364	1847

M.	39d.	51d.	M.	39d.	51d.	Min.	39d.	51d.
1	8	6	35	272	220	69	536	434
2	16	13	36	280	226	70	544	440
3	23	19	37	287	233	71	552	447
4	31	25	38	295	239	72	559	453
5	39	31	39	303	245	73	567	459
6	47	38	40	311	252	74	575	466
7	54	44	41	318	258	75	583	472
8	62	50	42	326	264	76	591	478
9	70	57	43	334	271	77	598	485
10	78	63	44	342	277	78	606	491
11	85	69	45	350	283	79	614	497
12	93	75	46	357	289	80	622	503
13	101	82	47	365	296	81	629	510
14	109	88	48	373	302	82	637	516
15	116	94	49	381	308	83	645	522
16	114	101	50	388	315	84	653	529
17	132	107	51	396	321	85	661	535
18	140	113	52	404	327	86	668	541
19	148	119	53	412	334	87	676	547
20	155	126	54	419	340	88	684	554
21	163	132	55	427	346	89	692	560
22	171	138	56	435	352	90	699	566
23	179	145	57	443	359	91	707	573
24	186	151	58	451	365	92	715	579
25	194	157	59	458	371	93	723	585
26	202	164	60	466	378	94	731	591
27	210	170	61	474	384	95	738	598
28	217	176	62	482	390	96	746	604
29	225	182	63	489	396	97	754	610
30	233	189	64	497	403	88	762	617
31	241	195	65	505	409	99	769	623
32	249	201	66	513	415	100	777	629
33	256	208	67	521	422	200	1554	1259
34	264	214	68	528	428	300	2331	1888

M.	40 d.	50 d.
1	8	6
2	15	13
3	23	19
4	31	26
5	38	32
6	46	38
7	54	45
8	61	51
9	69	58
10	77	64
11	84	71
12	92	77
13	100	83
14	107	90
15	115	96
16	123	103
17	130	109
18	138	116
19	146	122
20	153	129
21	161	135
22	169	141
23	176	148
24	184	154
25	192	161
26	199	167
27	207	173
28	214	180
29	222	186
30	230	193
31	237	199
32	245	206
33	253	212
34	260	219
35	268	225
36	276	231
37	283	238
38	291	244
39	299	251
40	306	257
41	314	263
42	322	270
43	329	276
44	337	283
45	345	289
46	352	296
47	360	302
48	368	309
49	375	315
50	383	321
51	391	328
52	398	334
53	406	341
54	414	347
55	421	353
56	429	360
57	437	366
58	444	373
59	452	379
60	460	386
61	467	392
62	475	399
63	483	405
64	490	411
65	498	418
66	506	424
67	513	431
68	521	437

Min.	40 d.	50 d.
69	529	443
70	536	450
71	544	456
72	552	463
73	559	469
74	567	476
75	574	482
76	582	485
77	590	495
78	597	501
79	605	508
80	613	514
81	620	521
82	628	527
83	636	533
84	643	540
85	651	546
86	659	553
87	666	559
88	674	566
89	682	572
90	689	579
91	697	585
92	705	591
93	712	598
94	720	604
95	727	611
96	735	617
97	743	623
98	751	630
99	758	636
100	766	643
200	1532	1286
300	2298	1928

M.	41 d.	49 d.
1	8	7
2	15	13
3	23	20
4	30	26
5	38	33
6	45	39
7	53	46
8	60	52
9	68	59
10	75	66
11	83	72
12	91	79
13	98	85
14	106	92
15	113	98
16	121	105
17	128	112
18	136	118
19	143	125
20	151	131
21	159	138
22	166	144
23	174	151
24	181	157
25	189	164
26	196	171
27	204	177
28	211	184
29	219	190
30	226	197
31	234	203
32	241	210
33	249	216
34	257	223

M.	41 d.	49 d.
35	264	229
36	272	236
37	279	243
38	287	249
39	294	256
40	302	262
41	309	266
42	317	275
43	324	282
44	332	289
45	339	295
46	347	302
47	354	308
48	362	315
49	369	321
50	377	328
51	385	334
52	392	341
53	400	348
54	407	354
55	415	361
56	422	367
57	430	374
58	438	380
59	445	387
60	453	394
61	460	400
62	468	407
63	475	413
64	483	420
65	490	426
66	498	433
67	506	439
68	513	446

Min.	41 d.	49 d.
69	521	452
70	528	459
71	536	466
72	543	472
73	551	478
74	558	485
75	566	492
76	574	498
77	581	505
78	589	512
79	596	518
80	604	525
81	611	531
82	619	538
83	626	544
84	634	551
85	641	557
86	649	564
87	656	571
88	664	577
89	671	584
90	679	590
91	687	597
92	694	603
93	702	610
94	709	616
95	717	623
96	724	629
97	732	636
98	739	643
99	747	649
100	755	656
200	1509	1312
300	2264	1968

M.	42d.	48d.
1	7	7
2	15	13
3	22	20
4	30	27
5	37	33
6	44	40
7	52	47
8	59	53
9	67	60
10	74	67
11	82	73
12	89	80
13	97	87
14	104	93
15	111	100
16	119	107
17	126	113
18	134	120
19	141	127
20	149	134
21	156	140
22	163	147
23	171	154
24	178	160
25	186	167
26	193	174
27	201	180
28	208	187
29	215	194
30	223	201
31	230	207
32	238	214
33	245	221
34	253	227

M.	42d.	48d.
35	260	234
36	267	241
37	275	247
38	282	254
39	290	261
40	297	268
41	304	274
42	312	281
43	319	287
44	327	294
45	334	301
46	342	308
47	349	314
48	357	321
49	364	328
50	372	335
51	379	341
52	386	348
53	394	354
54	401	361
55	409	368
56	416	375
57	423	381
58	431	388
59	438	394
60	446	401
61	453	408
62	461	415
63	468	421
64	475	428
65	483	435
66	490	442
67	498	448
68	505	455

Min.	42d.	48 d.
69	513	462
70	520	468
71	527	475
72	535	482
73	542	488
74	550	495
75	557	502
76	564	509
77	572	515
78	579	522
79	587	529
80	594	535
81	602	542
82	609	549
83	617	555
84	624	562
85	632	569
86	639	575
87	647	582
88	654	589
89	661	595
90	669	602
91	676	609
92	684	615
93	691	622
94	699	629
95	706	635
96	713	642
97	721	649
98	728	655
99	736	662
100	743	669
200	1486	1338
300	2229	2007

M.	43d.	47d.
1	7	7
2	15	14
3	22	20
4	29	27
5	36	34
6	44	41
7	51	48
8	58	54
9	66	61
10	73	68
11	80	75
12	88	82
13	95	89
14	102	95
15	110	102
16	117	109
17	124	116
18	132	123
19	139	130
20	146	136
21	153	143
22	161	150
23	168	157
24	175	164
25	183	170
26	190	177
27	197	184
28	205	191
29	212	198
30	219	205
31	227	211
32	234	218
33	241	225
34	248	232
35	256	239
36	263	245
37	270	252
38	278	259
39	285	266
40	292	273
41	300	280
42	307	286
43	314	293
44	322	300
45	329	307
46	336	314
47	344	320
48	351	327
49	358	334
50	366	341
51	373	348
52	380	355
53	388	361
54	395	368
55	402	375
56	409	382
57	417	389
58	424	395
59	431	402
60	439	409
61	446	416
62	453	423
63	461	430
64	468	436
65	475	443
66	483	450
67	490	457
68	497	464
Min.	43d.	47 d.
69	505	470
70	512	477
71	519	484
72	526	491
73	534	498
74	541	505
75	548	511
76	556	518
77	563	525
78	570	532
79	578	539
80	585	546
81	592	552
82	600	559
83	607	566
84	614	573
85	622	580
86	629	587
87	636	593
88	643	600
89	651	607
90	658	614
91	665	621
92	673	627
93	680	634
94	687	641
95	695	648
96	702	655
97	709	661
98	717	668
99	724	675
100	731	682
200	1463	1364
300	2194	2046

M.	44 d.	46 d.
1	7	7
2	14	14
3	22	21
4	29	28
5	36	35
6	43	42
7	50	49
8	58	56
9	65	62
10	72	69
11	79	76
12	86	83
13	93	90
14	101	97
15	108	104
16	115	111
17	122	118
18	129	125
19	137	132
20	144	139
21	151	146
22	158	153
23	165	160
24	173	167
25	180	174
26	187	181
27	194	188
28	201	195
29	209	201
30	216	208
31	223	215
32	230	222
33	237	229
34	245	236

M.	44 d.	46 d.
35	252	243
36	259	250
37	266	257
38	273	264
39	280	271
40	288	278
41	295	285
42	302	292
43	309	299
44	316	306
45	324	313
46	331	320
47	338	327
48	345	334
49	352	340
50	360	347
51	367	354
52	374	361
53	381	368
54	388	375
55	396	382
56	403	389
57	410	396
58	417	403
59	424	410
60	432	417
61	439	424
62	446	431
63	453	438
64	460	445
65	468	452
66	475	458
67	482	465
68	489	472

Min.	44 d.	46 d.
69	496	479
70	503	486
71	511	493
72	518	500
73	525	507
74	532	514
75	539	521
76	547	528
77	554	535
78	561	542
79	568	549
80	575	556
81	583	563
82	590	570
83	597	577
84	604	584
85	611	590
86	619	597
87	626	604
88	633	611
89	640	618
90	647	625
91	655	632
92	662	639
93	669	646
94	676	653
95	683	660
96	690	667
97	698	674
98	705	681
99	712	688
100	719	695
200	1439	1389
300	2158	2084

M.	45 d.	45 d.	M.	45 d.	45 d.	Min.	45 d.	45 d.
1	7	7	35	247	247	69	488	488
2	14	14	36	254	254	70	495	495
3	21	21	37	261	261	71	502	502
4	28	28	38	268	268	72	509	509
5	35	35	39	275	275	73	516	516
6	42	42	40	283	283	74	523	523
7	49	49	41	290	290	75	530	530
8	56	56	42	297	297	76	537	537
9	64	64	43	304	304	77	544	544
10	71	71	44	311	311	78	551	551
11	78	78	45	318	318	79	558	558
12	85	85	46	325	325	80	566	566
13	92	92	47	332	332	81	573	573
14	99	99	48	339	339	82	580	580
15	106	106	49	346	346	83	587	587
16	113	113	50	353	353	84	594	594
17	120	120	51	360	360	85	601	601
18	127	127	52	367	367	86	608	608
19	134	134	53	375	375	87	615	615
20	141	141	54	382	382	88	622	622
21	148	148	55	389	389	89	629	629
22	155	155	56	396	396	90	636	636
23	163	163	57	403	403	91	643	643
24	170	170	58	410	410	92	650	650
25	177	177	59	417	417	93	657	657
26	184	184	60	424	424	94	665	665
27	191	191	61	431	431	95	672	672
28	198	198	62	438	438	96	678	678
29	205	205	63	445	445	97	686	686
30	212	212	64	452	452	98	693	693
31	219	219	65	459	459	99	700	700
32	226	226	66	466	466	100	707	707
33	233	233	67	474	474	200	1414	1414
34	240	240	68	481	481	300	2121	2121

Now for the form of setting down a Reckoning, although he which is accustomed to keep it in this manner, may haply by use and practice discern how to order it in a better way then I can presently prestribe or think upon, because he hath occasion often to consider it in every particular: yet in the mean time I conceive it will be fit to have a Book in *Folio*, that is, two Leaves to a sheet of Paper, and to keep the left side of your Book void, that you may write therein all such Occurrents as you shall think requisite. As namely, the Winds, and the Points of the Compass, upon which your Ship lies, and what allowance you make for *Lee-ward* way when you Sail by a Wind, the number of Glasses or hours, and how many Knots or Miles in each hour, also the Latitudes which you find by Observation of the Meridian altitude of the Stars, and what else you shall think remarkable. But before all this, the title of the voyage in these or the like words,

The Journal of our Voyage intended by Gods assistance from S. I. *in the Latitude of* 32 deg 25 min. *to the Coast of* England, *&c.*

The right hand Pages, or the right side of your Book throughout, may by Lines be divided into 12 Cloumns, as in the Example following doth appear. In the first Column may be expressed the Day, in the second the Month; or at least once in the top of the Page; likewise in the same second Column, being large enough, may be set down the Latitudes which you find by the Meridian-altitudes of the Sun at such times as you make observation. In the 3 Column the Course (the *Lee-ward* way, if there be any Leeing allowed.) In the 4*th* variation of the Needle. In the 5*th* (having made allowance for the variation) set down the Angle of your Rumb with the Meridian. In the 6 Column set down the distance in Miles run upon that Rumb. In the 7, 8, 9, and 10 Columns the Northing or Southing, Easting or Westing, thereto answering, as you shall find it by your Table. In the 11*th* your Latitudes by dead reckoning. And lastly, in the 12 Column you may at such times as you think fittest, set down your *Longitude* from the place from which you first departed, or the difference of Longitude from place to place.

da.	Lat. by observation.	course	Variation.	Deg. fro the merid	dist. in miles	Nor.	Son.	East	Wes	Lat. by dead Reckonde.	Longitude.
20	February	N E by E	8deg. west	ne 48d	78	522		579		33.17	
21	Latitude 34 d. 25′	N E by E	8deg. west	ne 48d	100	669		743		34.24	
21	34 d. 25′			Summe is		1192		1322		34.24	02.38
22		e n e ½ poi.	8deg. west	ne 54d	100	588		809		35.56	
					56	329		453			
23	Latitude 37 d. 46′	e n e ½ no.	8deg. west	ne 54d	100	588		809		37.40	
					78	458		631			
24	Latitude 39 d. 36′	e n e ½ no.	8deg. west	ne 54d	100	588		809		39.28	
					84	494		679			
				Summe is		3045		4190			
		The correction by obser. is				80		110		08	
24	39.36					3125		4300		39.36	11.36
25	February	e n e	8deg. west	ne 59½	100	507		861		41.05	
					76	385		655			
26		e n e	8deg. west	ne 59½	100	507		861		42.37	
					80	412		586			
27	Latitude 43 d. 55	e n e	7½deg. west	ne 60d	100	500		866		44.09	
					84	420		728			
				Summe is		2731		4657			
				Correction		140		245	14		
27	L. 43. 55					2591		4412		43.55	21.28
28	February	e n e ½ e	6deg. west	ne 67 d	100	391		921		44.54	
					51	199		469			
29		e n e ½ e	5deg. west	ne 68 d	100	375		927		45.02	
					81	304		751			
1	March	e n e ½ e	4deg. west	ne 69 d	100	358		934		47.02	
					66	237		616			
2	La. 48. 4.	e n e ½ e	3deg. west	ne 71 d	100	326		946		48.00	
					78	254		737			
2	La. 48. 4.			Summe is		2444		6390		48.00	36. 38

da.	Lat. by ob. servacion.	courf.	Variation.	Deg. from the Mer.	dr. in miles	Nor.	Sou.	East	Weft	Lat. by. Longi-dead R.	rude.
3	March	e n e ½ e	0 de. weft	n e 73 d	52	152		497		48.44	
4		e n e ½ e	2 de East	n e 75 d	100 68	259 176		960 657		49.28	
5	Latitude 49.58 d.	e n e ½ e	3 de. East	n e 76 d	98	237		951		49.52	
5	la. 49.58			Summe is		1116		14027		49.52	46.52
5	8 Hours	n by e ½ e	4 de. East	n e 21 d	18	168		64		50.09	
6		South by e	4 de East	s e 7 d.	34		337	41		49.35	
6	16 Hours	n by east	4 de. East	n e 15 d	36	348		93		50.10	
7		s e by east	4 de. East	s e 52 d	20		158			49.58	
8	Latitude 50 d. 4'	East	4 de. East	s e 86 d	96		67	958		49.51	
	The current fetting by eſtima.	East nort. east.		n e 67½	60	230		554		50.14	
				Summe is		219		1868			
				Correction			100			10	
						119		1868		50 04	51.43
8	150 d. 4										
9		east ½ po. n	6 de East	s e 89½ d	70			60 700		49.58	
10		east ½ po. n	6 de East	s e 89½ d	52			41 520		49.54	
10	March			Summe is			1101	122 0		149.54	54.53
	Here the Lizard bears	N by E			13						

For an Example, we may frame a Reckoning between the two places before-mentioned, namely from *Summers-Islands* to the *Lizard*, whose distance in their Rumb we have before supposed to be 3299 Miles, as some Charts make it, and consequently their difference of Longitude 70 *deg.* I would not be understood as if I affirmed it to be so much, for I suppose it is less. I was there indeed about 20 years past, and Surveyed it, and than kept a Reckoning both outwards and homewards, but I have lost those Reckonings long since, and have forgotton what they were, and in this case it matters not; for whether the supposition be near the truth or not, it serves sufficiently to exemplifie the Rule, that being the end for which it is used. But if their distance be 3299 such Miles as contain only 1000 Paces in a Mile, the same being reckoned in such Miles, as we have before mentioned, namely, in such whereof 60 make a *degree* of a great Circle, which as we find contain 6120 Feet in a Mile, their distance will be little more than 2695 Miles, and consequently, the difference of Longitude little more than $55\frac{1}{3}$ *degrees.*

Let us therefore suppose the difference of Longitude between those two places to be 55 *degrees*, and their Latitudes to be the same as before, namely of the one 32 *deg.* 25 *min.* and of the other 50 *degrees.* And let the Courses, Distances, and other Observations from *Summers-Islands* to the *Lizard* to be such as before is shewed.

The first entrance in this Journal, (which is the 20 Day of *February*) is thus to be understood, namely, that from the time of setting Sail (which we suppose to be the 19 of *February*) till the 20 Day at Noon, the ship lies away, and makes her way good upon the Northeast and by East Point of the Compass; but the variation being 8 *degrees* to the Westwards (as in the fourth Column appears) the Rumb upon which she hath run is from the North to the Eastwards only 48 *deg.* as is expressed in the 5 Column (it is indeed $48\frac{1}{4}$ *deg.* but the $\frac{1}{4}$ *deg.* we omit, as for the other circumstances not to be regarded) upon this Rumb she runs 78 Miles, as in the 6 Column appears, and answerable thereto I find in the Table before-going, the Northing to be $52\frac{8}{10}$ miles,

and

and the Easting $57\frac{2}{10}$, as here in the seventh and ninth Column is expressed by these numbers 522 and 579 (for the first Figure towards the right hand signifyeth the tenth part of a Mile, the rest Miles.) Hence then the Northing being 52 Miles, if that be added to the Latitude from which it is reckoned, namely, 32 *deg.* 25 *min.* it makes the Latitude here to be 33 *deg.* 17 *min.* as in the 11 Column appears. In like sort, the second entrance being the 21 of *February*, sheweth that from the 20 Day at Noon to the 21, she made her way good upon the Northeast and by East Point of the Compass, but the Variation being 8 *degrees* Westerly, the Angle of the Rumb with the true Meridian was from the North to the Eastwards 48 *degrees*, and so Sailing 100 miles, the Northing is $69\frac{2}{10}$ miles, and the Easting $74\frac{1}{10}$ miles, so that the Latitude now is 34 *deg.* 24 *min.* and the like is to be understood of all the rest.

Touching the Longitude expressed in the last Column, although a reckoning may be kept and set down without it, yet it is of very good use; and how to convert the Easting or Westing (that is, the miles expressed in the East and West Columns of your Journal) into *degr.* and *min.* of Longitude; we will shew afterwards, as also how you may easily correct your Course, and give the true Course or Rumb, allowing the Variation.

But first to proceed with this Journal, observing the Meridian altitude of the Sun upon the 23 and 24 *February*, I find that my Latitude upon the 24, is 39 *deg.* 36 *min.* whereas by dead reckoning it is but 39 *deg.* 28 *min.* so the difference is 8 more Northerly: but being well assured of the Latitude found by Observation, I correct the dead reckoning thereby, which may be done by the Rule of Proportion, saying;

As the Sum of the North Column	3125	*Co. ar.* 6.505150
To the Sum of the East Column,	4300	3.633347
So the foresaid increase Northerly	80	1.903090
To the increase Easterly	110.	2.041717

That is, 11 miles: for the first place towards the right hand is only for the tenth parts of a mile.

The

The ſame may alſo ſufficiently be found without the Rule of Proportion, by the foregoing Table, only for looking there under the *degree* upon which I have Sailed, namely, under 54 *degr.* for 8 miles or 80 tenths of a mile, though I find not the ſame exactly, yet I find one which is near it, namely 82, and againſt it in the next collateral Column 113, which is $11\frac{3}{10}$ miles (being too much by $\frac{1}{10}$ of a mile, becauſe the other is too much by $\frac{2}{10}$) I add therefore in the North Column of the Journal 8 miles, and the Eaſt Column 11 miles; and ſo whereas by dead reckoning, the Northing was but $304\frac{2}{10}$ miles, and Eaſting 194 miles; now having corrected it by obſervation, the Northing is $312\frac{1}{10}$ miles, and Eaſting 430 miles.

In like ſort upon the 27*th* day, I ſhould by dead Reckoning be in the Latitude of 44 *deg.* 09 *min.* but by a clear and good obſervation I find my ſelf in the Latitude of 43 *deg.* 55 *min.* that is, not ſo much Northerly by 14 *min.* therefore to correct it I put in the South column 14 miles, or 140 tenths, and ſeeing my courſe was between the North and the Eaſt, and that I find my ſelf to be leſs to the Northwards, that is more to the Southwards than my reckoning; therefore in probability I am alſo leſs to the Eaſtwards, that is, more to the Weſtwards than my Reckoning; but to find how much, I look in the foregoing Table for the *degrees* upon which I have Sailed, being from the North part of the Meridian to the Eaſtwards 60 *deg.* and under 60 *deg.* I look for 14 miles, or 140 tenths, and againſt it in the Column adjoining I find 243, which I ſet down in my Journal in the Weſt Column, and ſo ſubſtracting the firſt from the North Column, the other from the Eaſt: I find that whereas by dead Reckoning I ſhould be to the Northwards $273\frac{3}{10}$ miles, and to the Eaſtwards $465\frac{7}{10}$. Now having corrected it by Obſervation, I find that from the 24*th* day till this time I have run more Northerly than I was by $259\frac{1}{10}$ miles, and more Eaſterly by $441\frac{3}{10}$ miles.

But if your Courſe be near the Eaſt or Weſt, it may ſuffice to correct it in Latitude only, as in the Example of the 8 of *March* appears; for in that caſe you cannot correct Longitude, but from ſome further ground.

If there be any Current, you may note it as is done in that Example following the 8th of *March*.

Now if you would set down this Reckoning upon the Plain or common *Sea-Chart*: First, if you desire to express every days account, you may begin for the 20 of *February*, and make a prick in your Plot that may be from the place from which you set Sail to the Northwards $52\frac{2}{10}$ miles, and to the Eastwards $57\frac{2}{10}$; and so will this Point be distant from the place of your setting sail 78 miles Northeast, and almost a quarter of a Point Easterly: then for the 21 day you may make another Prick, which may be from the form to the Northwards $66\frac{2}{10}$ miles, and to the Eastwards $74\frac{1}{10}$ miles, and so you may proceed with the rest. And thus you shall have a Prick on the Plot for every day more exactly set down, then could be done after the ordinary way by Course and Distance, or Course and Latitude, especially because in lining the Plot, there are not, nor cannot conveniently be drawn any more than the 32 Points of the Compass, *viz.* not half Points, quarters, or single *degrees*.

But if you desire not to set down every days reckoning (which is not necessary to be done) you may set down every of the sums, as they are corrected by observation after the self-same manner.

Or you may add together all those sums, and so the sum total of the North Column will be 1049 Miles, and of the East Column 2345 Miles, therefore in the Meridian of the place from which you depart, you may set down to the Northwards of that place 1049 Miles, which will fall in the Latitude of 49 *deg.* 54 *min.* almost, and from thence in that Parallel set down directly to the Eastwards 2345 Miles, and there make a Prick for the place where the Ship then is the tenth of *March*, and so is all this Reckoning set down at once.

If you keep Reckoning according to *Mercator*, it will be requisite sometimes to sum up your Reckonings past, namely, so often as you make any notable alteration in your Course; and so this Reckoning or any other may be set down almost as easily on *Mercator's Chart*; the difference is, that here you must often alter your *Scale*, because the *deg.* of Latitude on this *Chart* are not

equal,

equal, but grow greater and greater towards the Poles. Now then the distance of two places is to be measured by that part of the Meridian, which is intercepted between the Latitudes of those two places; Or if both places lie in one and the same Latitude, their distance is measured by a *degree* or other less quantity, taken about that Latitude; namely, half above, and half beneath.

Wherefore if you would make a Prick or Traverse-point in *Mercators Chart*, answering to your reckoning for the first day, namely, untill the 20 of *February* at Noon; it appears by your Journal that Prick must be to the Northwards of the place from which you departed $52\frac{8}{10}$ miles, and to the Eastwards $57\frac{8}{10}$ miles.

Now, instead of the North or South Columns, you may more conveniently use the last Column but one, shewing in what Latitude every account doth fall; and so it appears, that the Prick for the 20 of *February* must be in the Latitude of 33 *degr.* 17 *min.* Therefore in the Meridian of the *Summers Islands* from which you departed, make a Prick in the Latitude of 33 *deg.* 17 *min.* and from that Prick set down to the Eastwards in the same Latitude $57\frac{8}{10}$ miles, and where it ends is the Traverse-point answering to the 20 of *February:* the like may be done for the 21 Day, and so for all the rest. This 58 miles may be taken in the Meridian from the Latitude of 32 *degr.* 22 *min.* to the Latitude of 33 *deg.* 20 *min.* or otherwise you may take the half of it, which is 29 miles about the middle between both Latitudes and double it.

But it is sufficient to set down the sums of every two or three days accounts, or so often as there is any notable Difference in your Course. Thus if you would make a Prick in the *Chart*, answering to the 21 of *February*, being the first sum; I see by the Journal, that it must be in the Latitude of 34 *deg.* 24 *min.* and to the Eastwards of the place from which I departed $132\frac{8}{10}$ miles. Therefore in the Meridian of the place from whence I departed, I make a Prick in the Latitude 34 *degr.* 24 *min.* and from that Prick I set in the same Latitude to the Eastwards $132\frac{8}{10}$ miles, and where it ends is the Traverse-point answering to the 21 of *February*, being the first sum. This 132 miles may be taken in the Meridian within, or a little without the two Latitudes, as before, namely, from 32 *deg.* 20 *min.* to 34 *deg.* 32 *min.*

In

In like sort, if you would make a Prick for the second sum, being the 24 of *February*, it there appears that it must be in the Latitude of 39 *deg.* 36 *min.* and to the Eastwards of the Traverse-Point last before made 430 miles, therefore in the Meridian of that Traverse-point I make a Prick in the Latitude of 39 *deg.* 36 *min.* and from that Prick I set to the Eastwards in the same Latitude 430 miles, and where that ends is the Traverse-Point answering to the 24 Day, and the like is to be understood of all the rest.

Now this 430 miles may be taken several ways; for first, if I take one *Degree* about the middle of that part of the Meridian, which is intercepted between the Latitudes of the two places, (as from 36 *deg.* 30 *min.* to 37 *deg.* 30. *min.*) and that *degree* seven times taken, is 420 miles, then about the middle, namely, 37 *deg.* I take 10 *min.* more, and so I have 430 miles.

In like manner you may take two *deg.* or 120 miles to measure it thereby, which may be taken from 36 *degrees* to 38 *deg.* and the residue about 37 *degrees*, as before, *&c.*

Or you may take the half of 430 miles, namely, 215 miles, which is 3 *deg.* 35 *min.* which must be taken as before, about the middle of that part of the Meridian which is intercepted between the two Latitudes, and that doubled is 430 miles to be set to the Eastwards, as before.

And thus may this or any other Reckoning be set down without knowledge of the Longitudes, but more aptly and exactly by some Longitudes known, for then shall you have in the two last Columns the substance and principal scope of your Reckoning, namely, the Latitudes and Longitudes of all places, as you Sail, which may more easily and exactly be express'd upon this *Chart*, then the Easterly or Westerly distances. Therefore how this also may be done, we will shew, but first something touching the *Compass*, and the Variation thereof, which ought not to be neglected in a Reckoning.

Of the Variation of the Compaſſe, and how to rectifie a Courſe by the Variation known.

AMongſt all the myſteries which God hath of late years diſcovered to the World for the furtherance of *Navigation*, there is none more neceſſary, nor yet more admirable than that property of the *Needle* touched with the Load-ſtone, whereby in the vaſt Ocean, where all Land-marks fail, yea even in the darkeſt nights and cloſeſt weather, when neither Sun nor Stars are to be ſeen, the Mariner (as it were by a Meſſenger ſent from Heaven) is taught which way to direct his Ship; yea, as it were accompanied with a guide towards his deſired Port.

For the Needle touched, beſides other ſtrange properties, hath this, to point out in all quarters of the World, the North and South parts of the Horizon, and ſo having a Card thereto fitted with Rumbs and degrees, it ſheweth all points of the Compaſs, and degrees of the Horizon.

Yet very ſeldom exactly of it ſelf, without ſome farther Art and Induſtry of him that uſeth it, for though in ſome places it ſwerves not, yet in moſt parts of the World the North and South points of the Needle have ſome *Variation* from the true North and South points of the Horizon to the Eaſtwards or to the Weſtards, which how to diſcover in kind and quantity, we have ſhewed heretofore.

It may be thought, (and ſome men, otherwiſe learned, before this property was fully diſcovered, have ſaid) that this ſhould be ſome blemiſh and imperfection in a ſtone ſo precious: but it is ſo far from being an imperfection, that it makes it ſo much the more precious. Yet (as I have ſaid) not without the induſtry of him that uſeth it. He that is negligent or unskilful to obſerve it, eſpecially in long Voyages and various Courſes, may be led into many dangers by it, becauſe he frames not his mind to the Rule, but the Rule to his Mind, imagining it to be what it is not: and

and hence I suppose sprang that custome of placing the *Needle* or *Wyars* a point or half a point to the Eastwards of the North-point of the Card, thinking by this means to shun the labour of observing the Variation, which indeed they might, if the Variation were the same in all places, and at all times, but because it is not, this doth often increase the Errour.

But he that diligently observes the Variation, finds (as I say) no prejudice in it, onely it requires daily, or once in two or three dayes half an hours work, and this labour it doth abundantly recompense, for by this means he knows at the present how to direct his Course, and for the future, by those notes which he keeps of the *Variations* and *Latitudes* by him observed, he knows (coming that way again) when he draws neer to any of those places where such Observations were made, and so falls the more certainly with any place intended.

There is further discovered of late a motion or alteration in the Variation of the *Needle*, and this is scarce yet certainly discovered. But comparing the Variations which were observed about fifty years past, with the present Variations, it appears they are lesser Easterly, and more Westerly by 6 or 7 degrees, than they were at that time. For whereas the Variation hath formerly been observed neer *London* to be $11\frac{1}{4}$ *degr.* to the Eastwards, it doth now scarce exceed 4 Degrees. And there is the like alteration (as I have heard by some Mariners) in other parts of the World, which we now leave to the further discovery of time and industry, and come to shew how to rectifie a Course by the Variation known.

The point of the Compasse upon which you sail, and the Variation of the Needle known, to find the Rumb or Degree upon which the Ship hath made her way.

IT is best that the *Needle* or *Wyars* be placed directly under the *Flower-de luce*, or *North* and *South* points of the *Card*, and so in the Rules following we presuppose them to be. Now then it is to be understood, that the *Needle*, having Variation

(as for the most part it hath) the Ship doth not make her way upon the Rumb or Point of the Compass, which she seems to sail upon, but either more to the right hand or to the left, according as the Variation is towards the right hand, or towards the left, and that so much towards the one side, or towards the other as that Variation is: We speak not here of Lee-ward way, but of the Variation only. Therefore for the solution of this *Problem*, you must know how much the variation is, and which way; and how this may be done, we have briefly shewed upon the 12 Case of *right angled Spherical Triangles*, and the 11 of *oblique*, which known, you may find the angle of the *Rumb* or line of your Ships way with the *Meridian*, being the thing in this *Problem* required.

A Table of the Angles of every Point and half Point of the Compass with the Meridian.

	North.	South.	D. M.	North.	South.
			00 00		
½			05 37		
1	N by E	S by W	11 15	N by W	S by E
1½			16 52		
2	N N E	S S W	22 30	N N W	S S E
2½			28 07		
3	N E by N	S W by S	33 45	N W by N	S E by S
3½			39 22		
4	N E	S W	45 00	N W	S E
4½			50 37		
5	N E by E	S W by W	56 15	N W by W	S E by E
5½			61 52		
6	E N E	W S W	67 30	W N W	E S E
6½			73 07		
7	E by N	W by S	78 45	W by N	E by S
7½			84 22		
8	East.	West.	90 00	West.	East.
	Add East Variation, Substract West.			Add West Variation, Substract East.	

For

For the effecting whereof, we will set down two ways, the one by the Pen alone, the other instrumentally. If you do it by the Pen alone, although it be not hard to find what Angle every Point or half Point makes with the Meridian; yet for your further ease herein, I have expressed the same in the Table before-going, the quarters of Points I have omitted, because the Steerage upon a quarter of a Point is very uncertain (the Points being undivided as usually they are) for a man by his eye is able to guess very nearly which is the middle between two points, but he cannot guess so nearly which is the fourth part. Yet if you desire any quarter, you may add to the next before-going almost 3 *degrees*, namely, 2 *degr.* 49 *min.*

Now then by the Magnetical Rumb or Point of the Compass and Variation given, to find the true Rumb, you are to observe these two Rules following.

1. *If the Rumb and the Variation be both the same way from the Meridian (namely, both to the right hand, or both to the left) add them together, and that sum is the true Rumb from that part of the Meridian.*

Yet if that sum exceed 90 degrees, *Substract it from* 180 degrees, *the remainder is the Rumb from the opposite part of the Meridian.*

2. *If the one be towards the right hand, the other towards the left, Substract the Variation from the Rumb, and the remainder is the true Rumb.*

Yet if the Rumb be the smaller number, Substract it from the Variation, and the remainder is the true Rumb his other way.

These Rules we shall endevor to illustrate by examples following.

But first for distinction sake, we say the Rumbs or *degrees* from the North towards the East, are towards the right hand, and so from the South towards the West, but from the North to the Westwards, on the left hand, and so from the South Eastwards. For a mans face being towards the North, the East is on his right hand, and the West on his left, *&c.*

In like sort for the *variation of the Compass*, if it have Easterly *variation*, that is, if the *Needle* and *Flower de luce* of the *Card*

stand

ſtand to the Eaſtwards of the North, we ſay that *Variation* is towards the right hand, for not onely the North-point, but all the other points of the *Compaſſe* direct a Courſe more towards the right hand than they would do, if there were no *Variation*. And ſo if it have Weſterly *Variation*, that is, if the *Needle* and *Flower de luce* ſtand to the Weſtwards of the true North-point of the *Horizon*, we ſay that *Variation* is towards the left hand; foraſmuch as not only the North point, but all the other points of the Compaſſe, ſtand more towards the left hand than they would do, if there were no *Variation*. This being premiſed, we come to give *Examples* of the two Rules before-going.

1. Let the Magnetical Rumb or point of the *Compaſſe* be North-eaſt, and the *Variation* 10 degrees to the Eaſtwards; I demand the true *Rumb*?

Here the *Rumb* and *Variation* are both one way, that is, both towards the right hand; therefore,

To the Magnetical Rumb being N. Eaſterly	45	*deg.*	0 *m.*
Add the Variation Eaſterly	10	*deg.*	0 *m.*
The ſumme is the true Rumb N. Eaſterly	55	*deg.*	0 *m.*

2. Admit a Ship ſail upon the North-point of the Compaſſe, and that the Variation be 10 deg. to the Eaſtwards, how doth ſhe make her way?

The Magnetical Rumb is North, that is,	00	*deg.*	0 *m.*
To which adding the Eaſterly Variation	10	*deg.*	0 *m.*
The ſumme is the angle from the North-part of the Meridian to the Eaſtwards	10	*deg.*	0 *m.*

Which is almoſt N. by *E*, and ſo hath the Ship made her way.

3. Let the point of the Compaſſe be Eaſt $\frac{1}{2}$ point Northerly, that is, from the North to the Eaſtwards $7\frac{1}{2}$ points, which is 84 deg. 22 min. and the Variation as before 10 deg. to the Eaſtwards, I demand the true Rumb?

To the magnetical Rumb being North-eaſt,	84	*deg.*	22 *m.*
Add the Eaſterly Variation	10	*deg.*	00 *m.*
The ſumme is the angle from the North	94	*deg.*	22 *m.*
Which ſubſtracted from	110	*deg.*	00 *m.*
There reſts the true Rumb South-eaſterly	85	*deg.*	38 *m.*

4. *Ex-*

4. *Example.* Let the course by the compasse be West and by South, that is, 7 points from the South to the Westwards, or 78 deg. 45. min. and let the Variation be as before 10 deg. to the Eastwards, what is the true Rumb?

To the Magnetical Rumb *South Westerly*	78 *deg.* 45 *min.*
Add the *Easterly Variation*	10 *deg.* 00 *min.*
The summe is the true Rumb *South Westerly*	88 *deg.* 45 *min.*

You may conceive that the *Rumb* and *Variation* are here both one way; namely, both from the *Meridian* towards the right hand. For the Variation of the *North* point is from the *North* towards the *East*, and consequently of the *South* point from the *South* towards the *West*, both towards the right hand of the *Meridian*, as the *Rumb* is.

5. *Example.* Let the course by the *Compass* be *West*, that is, from the *South* to the *Westwards* 8 points or 90 degrees, and let the Variation be as before 10 deg. to the *Eastwards*, I would know the true Course or *Rumb*?

To the magnetical Rumb South-west	90 *deg.* 0 *min.*
Add the Variation *Easterly*	10 *deg.* 0 *min.*
The summe is the angle with the *South*-part of the *Meridian*	100 *deg.* 0 *min.*
Which substracted from	180 *deg.* 0 *min.*
There rests the true Rumb *N. West*	80 *deg.* 0 *min.*

Let the Course by the *Compass* be *West*, that is from the *North* to the *Westwards* 8 points or 90 degrees, and let the *Variation* be 10 deg. to the *Westwards*; I demand the true *Rumb*?

To the magnetical Rumb *N. West.*	90 *deg.* 0 *min.*
Add the Variation *Westerly*	10 *deg.* 0 *min.*
The summe is	100 *deg.* 0 *min.*
Which substracted from	180. *deg.* 0 *min.*
There remains the true Rumb *S. West*	80 *deg.* 0 *min.*

Object. The Magnetical Rumb being here West 90 deg. why could it not as well be counted from the *South* as from the *North*?

Answ. It may be counted from either, for as it is counted here from the North to the Westwards, it falls under the first *Rule*, because

becauſe the Variation is the ſame way: But if it be reckoned from the South to the Weſtwards, it falls under the ſecond Rule, whereof we now come to give ſome Examples, ſuppoſing theſe already given ſufficient to illuſtrate the firſt Rule.

7 *Example.* Let the Point of the Compaſs be N N W, and the Variation 10 *deg.* Eaſterly, I demand the true Rumb:

From the magnetical Rumb N W	22 *deg.* 30 *min.*
Subſtract the Eaſterly Variation	10 *deg.* 00 *min.*
The Remainder is the true Rumb N W	12 *deg.* 30 *min.*

8 *Example.* Let the Point of the Compaſs be North, and the Variation Eaſterly 10 *deg.* what is the true Rumb?

From the Eaſterly Variation	10 *deg.* 00 *min.*
Subſtract the magnetical Rumb N W.	00 *deg.* 00 *min.*
The Remainder is the true Rumb, the other way, namely N E	10 *deg.* 00 *min.*

Object. The magnetical Rumb may as well be named North-eaſterly 0 *deg.* 0 *min.*

Anſ. It may, but then it is ſubject to the firſt Rule, as in the ſecond *Example.*

9 *Example* Let the Courſe of the Compaſs be Weſt, that is, from the North to the Weſtwards 8 Points, or 90 *degrees*, and let the Variation be as before 10 *degrees* to the Eaſtwards, what is the true Rumb?

From the magnetical Rumb N W	90 *deg.* 00 *min.*
Subſtract the Eaſterly Variation	10 *deg.* 00 *min.*
There reſts the true Rumb N W	80 deg. 00 *min.*

Here the magnetical Rumb might as well have been South-weſterly 90 *degr.* and ſo it had fallen under the firſt Rule, as in the fifth Example.

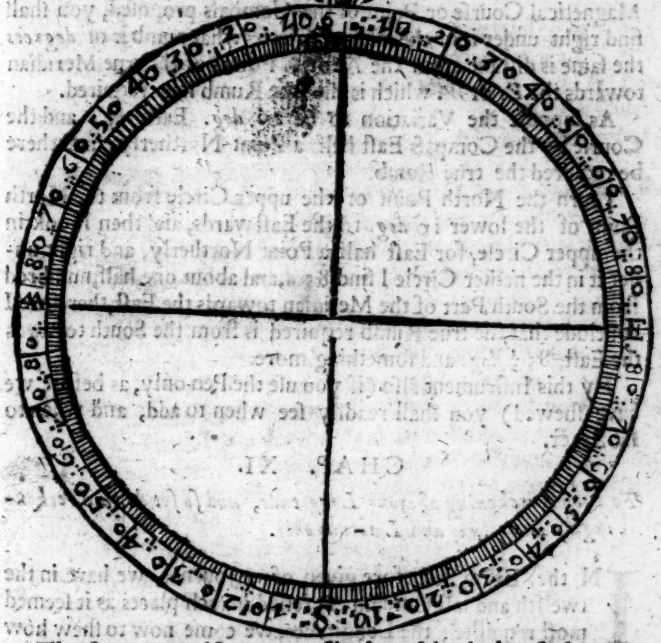
10 *Example.* Let the Courſe by the Compaſs be Weſt, that is, from the South to the Weſtwards 8 Points or 90 *degrees*, and let the Variation be 10 *deg.* to the Weſtwards, I demand the true Rumb?

From the magnetical Rumb S W	90 *deg.* 00 *min.*
Subſtract the Weſterly Variation	10 *deg.* 00 *min.*
The remainder is the true Rumb S W	80 *deg.* 00 *min.*

If

If the Rumb here had been reckoned from the North, as in the ſixth Example, it had fallen under the firſt Rule.

And this may ſuffice for the illuſtration of the two former Rules in the ſolution of this Problem.



The ſame may alſo more eaſily be reſolved, by ſuch an Inſtrument as is here deſcribed, conſiſting of two Circles, the one being the nethermoſt divided into four Quadrants, and every of thoſe into 90 *deg.* numbred from the North and South Points, towards the Eaſt and Weſt.

The other being the uppermoſt and moveable about the *Centre* divided, as the Card of the Compaſs into XXXII Points, and thoſe again ſub-divided into halves and quarters.

By this you may readily find the true Rumb for any Course and Variation given.

For if you turn the North Point of the upper Circle, from the North Point of the lower, so many *deg.* and the same way that the Variation is, and then look in the same upper Circle for the Magnetical Course or Point of the Compass proposed, you shall find right under it in the nether Circle what number of *degrees* the same is distant from the *N.* or *S.* Points of the true Meridian towards the *E.* or *W.* which is the true Rumb here required.

As suppose the Variation to be 10 *deg.* Easterly, and the Course by the Compass East half a Point Northerly, and there be required the true Rumb.

I turn the North Point of the upper Circle from the North Point of the lower 10 *deg.* to the Eastwards, and then I look in the upper Circle, for East half a Point Northerly, and right under it in the nether Circle I find 85 *d.* and about one half, numbred from the South Part of the Meridian towards the East, therefore I conclude that the true Rumb required is from the South towards the East, 85 ½ *deg.* and something more.

By this Instrument also (if you use the Pen only, as before we have shewed) you shall readily see when to add, and when to substract.

CHAP. XI.

To keep a reckoning of your Longitude, and so set down a reckoning by Longitude and Latitude only.

IN the Example before given of a Journal, we have in the twelfth and last Column expressed in such places as it seemed most requisite, the Longitudes, we come now to shew how the same may be known, and first,

By the Rumb and latitudes given to find the difference of longitudes.

As Radius is in proportion, to the Tangent of the Rumb;
So is the difference of Latitude in Meridional parts,
To the difference of Longitude in Minutes.

As let the Rumb be North-easterly 48 *deg.* and suppose a Ship to run upon this Rumb, from the Latitude of 32 *deg.* 25 *min.*

into,

into the Latitude of 34 *deg.* 24 *min.* there is required the difference of Longitude. Here,

The Meridional parts answering to	34 *deg.*	24 *min.*	2200
The Meridional parts for	32	25	2058
The difference of Latitude in such parts is			142

Say then, as *Radius* is to proportion

To the Tangent of the *Rumb*, t,	48 *deg.* 0 *min.*	10.0456
So the difference of Latitude in Merid. parts	142	2.1523
To the difference of Longitude in Minutes	158	2.1979

These Minutes converted into *deg.* are 2 *deg.* 38 *min.* which is the difference of Longitude required, as the same is expressed in the Journal against the 21 of *February*.

And thus Sailing upon one and the same Rumb, you may find the difference of Longitude, and so often as you alter your Rumb, so often working by the same Rule, you shall have all the differences from place to place, which added together, make the whole difference of Longitude.

But you may also find the difference of Longitude near enough at one operation for many several Rumbs and Distances, provided that those Rumbs differ not much one from another. As in the former Journal from the 27 of *February*, till the 2 of *March*, I Sail by several Rumbs and Distances from the latitude of 43 *deg.* 55 *min.* into the Latitude of 48 *deg.* if you would find the difference of Longitude hereto answerable at one operation, it may be done by this Rule.

As the difference of Longitude in Miles,
Is to the departure from the Meridian in Miles,
So is the difference of Latitude in Meridional parts,
To the difference of Longitude in Minutes.

As in that Example, the difference of Latitude for all those Courses, as in the Notth Column appears, is 2444.

The departure from the Meridian, as there in the East Column appears, is 6301.

The Merid. parts for the Latitude of	43 *deg.* 45 *m.*	are 2939
The Merid. parts for the Lanitude of	48 *deg.* 0 *m.*	are 3292
Difference of Latitude in Meridional parts, is		353

Say then, As the difference of Latitude 2444 *co. ar.* 6.6119
To the departure from the Meridian 6301 3.7994
So the difference of Latit. in Merid. parts 352 2.5478
To the difference of Longitude in *min.* 910 2.9591

Which reduced into *degrees*, is 15 *deg.* 10 *min.* And added to the former Longitude 21 *deg.* 28 *min.*
Gives the present Longitude 36 *deg.* 38 *m.* for the 2 of *March*.

The like may be done for the account from the 2 of *March*, to the 5 of the same, *&c.*

But if your courses and Distances run, be all near to one and the same Parallel or Latitude (as in this Journal they are from the 5 of *March* to the 8, and from the 8 to the 10,) then it is sufficient to find what Longitude in that Parallel is answerable to the miles of Easting or Westing, or departure from the Meridian by this Rule.

As the Sine Complement of the Latitude of that Parallel,
Is in proportion to *Radius*,
So is the number of Miles in that Parallel,
To the difference of Longitude in Minutes.

As from the 5 of *March* to the 8, the Latitude was near 50 *deg.* the Easterly distance 186 $\frac{8}{10}$ miles: therefore for the difference of Longitude, say:

As Sine Complement the Latitude, *i. e.* 50 *deg.* 0 *min.* 1919
To *Radius*,
So is the departure from the Meridian 186 8 3.2714
To the difference of Longitude 290 6 3.4633

Thus it appears, the difference of Longitude is almost 291 *min.* which is 4 *deg.* 51 *min.* and this added to the Longitude upon the 5 of *March* namely, to 46 *deg.* 52 *min.* the sum is 51 *deg.* 43 *min.* the Longitude upon the 8 of *March*: the like might be done for the 10 of *March*.

And though this last Rule be then fittest to be used, when your Course is near East and West, or your difference of Latitude little, yet it may also be used at other times instead of the two former, without any great Errour, if you take the middle *degree* of Latitude, or somewhat more, as in the former Example.

The Latitude upon the 27 of *February* is 43 *deg.* 55 *min.*
The Latitude upon the 2 of *March* is 48 *deg.* 00 *min.*
The middle Latitude or somewhat more is 46 *deg.* 10 *min.*
Say then, as fine Comp. the Latitude *s. c.* 46 *deg.* 10 *m.* 1595
To Radius,
So the Easting or departure from the Merid. 620. 1. 2.7904
to the difference of Longitude, 909. 7. 3.9589
Which is almost 910 *min.* or 15 *d. g.* 10 *min.* as before,

And thus you may in the 12 and last column of your Journal set down your Longitude so often as you think it requisite; and so in the two last Columns you shall have the substance and principal scope of your Reckoning, namely, your Latitudes and Longitudes, which whensoever you desire to set down in *Mercator's Chart*, or in the *Polar Chart*, or in any other graduated with *degrees* of Longitude and Latitude, you may readily do it.

As if I would set down the sum of the foresaid Journal from the 19 of *February* to the 10 of *March*, I find against the 10 of *March* the Latitude to be 49 *deg.* 54 *min.* and the difference of Longitude 54 *deg.* 53 *min.* Therefore in the Latitude of 49 *deg.* 54 *min.* I draw an occult Parallel, and reckoning from *Summers-Islands* towards the East 54 *deg.* 53 *min.* I draw by that Longitude an occult Meridian, the Intersection of this Meridian with the foresaid Parallel, is the Traverse-point, or the point representing the place of the Ship, and the like is to be understood of any other.

This form of keeping and expressing a Reckoning, is (as I conceive) most apt and agreeable (of all others that I have seen or thought upon) to all sorts of *Charts* or Maps, and to the *Globe* it self; and to all the kinds or ways of Saling, that are or may be used. We will here add some other Propositions which may sometimes be of good and necessary use in it.

The Rumb and Difference of Latitude given: to find by the Table, the Distance in the Rumb, and the Departure from the Meridian thereto answerable, &c.

HOw to find the Northing or Southing, that is, the distance in Latitude; as also the Easting or Westing, that is, the Distance

ſtance in Longitude, or departure from the Meridian of any Rumb, for any diſtance run upon it, we have before ſhowed, the like operation is in theſe Propoſitions following: namely.

2. *The Rumb and diſtance in Latitude given: to find the diſtance in the Rumb, and the Eaſting or Weſting.*

3. *The diſtance and difference in Latitude given: to find the departure from the Meridian and the Rumb.*

4. *The difference in Latitude, and departure from the Meridian given: to find the Courſe and Diſtance.*

5. *The Courſe and departure from the Meridian given: to find the difference of Latitude and Diſtance.*

6. *The diſtance and departure from the Meridian given: to find the Courſe and difference of Latitude.*

So that with the firſt before-handled, here are ſix Propoſitions, and in every of them two things required; and ſo they become 12. We will not ſtand to give examples of them all, but only of thoſe which are moſt uſeful, the reſt may by them be conceived.

And firſt, to find the Eaſting or Weſting of any Rumb for any difference of Latitude.

Admit a Ship run North-eaſterly 60 *deg.* (that is *N E* by *E*, and almoſt half a Point Eaſterly) till ſhe have altered the Latitude 42 *min.* how much is ſhe departed from the Meridian?

I run down the Column under 60 *deg.* till I find 42 miles, or 420 tenths, and againſt it in the adjacent Column I find 728 tenths, that is almoſt 73 miles, which is the departure from the Meridian to the Eaſtwards.

If you would alſo have the diſtance upon the Rumb, it is right againſt theſe numbers in the Column of Diſtances, being in this Example 84 miles.

2 *Example.* But admit ſhe run North-eaſterly 60 *deg.* till ſhe alter her Latitude 1 *deg.* 32 *min.* what is the Eaſterly diſtance?

This 1 *deg.* 32 *min.* is 12 miles, or 920 tenths, for which if I look in the Col. under 60 *d.* I find no number ſo great, but the greateſt number there is 500, which ſubſtracted from 920, there remains 420, therefore in that Column under 60 *deg.*

100 580 826
84 420 728
104 920 1594.

I look for these two numbers, namely, 500, and 420, and against the first in the adjacent Column I find 866, and against the second 728, which I set against them as above appeareth, and so adding them, I find for this difference of Latitude, the departure from the Meridian to be $159\frac{4}{10}$ miles.

If further you desire the distance run upon this Rumb, you have it in the Column of Distances, right against the same numbers, as in the example above appeareth, where being added, it amounts to 184 miles.

The distance and difference in Latitude given: to find the Rumb and departure from the Meridian.

ADmit a Ship run upon some Rumb between the North and the East 84 miles, and then have altered her Latitude 42 *min.* the Question is, upon what Rumb hath she run, and how many miles is she to the Eastwards in Longitude?

I run cross the Table towards the right hand, looking in every first Column of Distances for 84, till I find against it in one of the adjacent Columns 420, at the top of which Column over 420, there is 60 *deg.* shewing the Rumb to be North-easterly 60 *deg.* also against 420 in the adjacent Column I find 728, which sheweth the distance to the Eastwards to be almost 73 miles.

2 *Example.* But if the distance run be 184 miles, and the difference of Latitude 1 *deg.* 32 *min.* and there be required the Rumb and Distance to the Eastwards.

Because the Column of Distance extends but to 100 miles and the distance here given is 184 miles, you may take the half thereof, which is 92 miles, and likewise the half of 1 *deg.* 32 *min.* which is 46 miles, or 490 tenths, and then look, as before, where you find 460 against 92, for there in the top of the Column you shall find the Rumb, which in this example is 60 *deg.* shewing that the Rumb is from the N. easterly 60 *deg.* and in the adjacent Column against 92 and 460. you shall find 797, which doubled (because it is for the half) is 1594, shewing that the departure from the Meridian to the Eastwards is $159\frac{4}{10}$ miles. These and the rest may also be performed by the *Doctrin of plain Triangles*, as we have formerly shewed.

CHAP.

CHAP. XII.

Certain Problems touching Currents.

ALthough the time be already expired which I assigned for this Work, and mine own more urgent occasions call me away, yet seeing it is necessary in *Navigation* to take notice of Currents, and to make a competent allowance for them: I will briefly set down certain *Problems*, such as I have sometimes thought upon, whereby a man may the better conceive and judge of that allowance, the rather for that I know not any that have handled it.

First then, it is to be conceived, that a Ship or other Vessel Sailing or Rowing where there is a Current, hath a compound motion arising of two different Principles; namely of the Current and Ships way, so that here are three motions to be considered, namely, two simple, and the third compounded of them. The first simple motion is that of the Current, whereby it moveth, and is apt to move other things that are in it the same way. The 2 of the Ship or Boat, as it moveth by wind or Oars, or is apt to be moved, if there were no Current. The 3 compounded of them, is the Line of the Ships true motion. The 1, we call the way, or motion of the Current: The 2, the way, or simple motion of the Ship: The 3, her compound or true way. The 2 simple motions being either of them according to right Lines and uniform (as in the *Problems* following we suppose them to be.) The third also, which is composed of them is a right Line; for whether the Ship Sail directly opposite against the Current, or directly with the same way, or whether the one cross the other at right Angles or at oblique: yet still either motion being direct and uniform, they both together beget a right lined uniform motion, because the one retaineth to the other the one and the same proportion in every Point. And according to these grounds we proceed in the *Prob.* following, to determine the proportions of every of these motions, and the Angles which they make one with another.

1. *Ad-*

1. *Admit a Current run East 3 Miles an hour, and that a Ship under Sail run West directly against in 6 Miles an hour in her simple motion, what is her true or compound motion?*

From the Ships simple motion	6 miles
Subtract the Current	3 miles
The Remainder is the Ships true motion	3 miles

So the Ships true way is to the Westwards 3 miles an hour.

2. *Admit a Current run West 6 Miles an hour, and that a Ship under Sail run directly against it 5 Miles an hour by the Log: what is the Ships compound motion, and which way?*

From the Current being the greater	6 miles
Subtract the Ships simple motion	5 miles
The Remainder is the Ships true motion	1 mile

Which 1 mile shews, that the Ship by her compound motion falls astern, that is, moves to the Westwards 1 mile an hour.

In the experimental Practice of the two former *Problems*, it may seem, that a Ship or Boat so ordered, hath also a motion to the right hand or to the left; but this comes to pass, because it is hard, and in a manner impossible to stem a Tide or Stream so exactly, but that the Ship will swerve, (or yaw as they say) either to the one side or to the other.

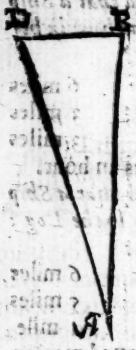
3. *Admit a Current run East 3 Miles an hour, and that the Ship also run East 3 Miles an hour by the Log: what is the Ships true motion?*

To the Ships simple motion	3 miles
Add the Current	3 miles
The Sum is the Ships true motion	6 miles

So the Ships compound or true way is East 6 miles an hour.

4. *Admit a Current run East 3 Miles an hour, and the Ship South 6 Miles an hour; what is the Ships true motion, and which way?*

In handling of any Art, to avoid circumlocution, there are used Terms or Words of Art, serving to express briefly the things handled. And forasmuch as this Subject hath not been formerly handled, nor the Principles or Grounds thereof laid (so far as I know) we will add a few such terms as may seem most necessary, pressing here what we mean by them.



Let the Line *A B* run from *A* to the Southwards, and *B D* from B to the Eastwards, and let *A B* be in proportion to *B D*, as 6 to 2, or 3 to 1.

Then doth *A B* represent the line of the ships simple motion, *B D* the motion of the Current, and *A D* the compound motion of the Ship.

And *D A B* is the Angle contained between the line of the Ships simple motion, and the line of her compound or true motion, which for brevity sake we will henceforth call the *Angle of Deflection*. Also *A D B* is the angle contained between the line of the ships compound motion, and the set or drift of the Current, which we call the *Angle of Reflection*.

Lastly, *A B D* is the angle contained between the line of the ships simple motion, and the set of the Current, which we will call the *Angle of Incidence*.

Thus for the Rumb, the proportion is thus.

As the simple motion	*A B* 6 miles	*co. ar.*	9.2219
Is to the Current	*B D* 2 miles		0.3011
So is *Radius*			
To the Tangent of Deflection	*D A B* 18 *deg.* 26 *min.*		9.5230

So the Rumb upon which the Ship makes her way good is South 18 *deg.* 26 *min.* Easterly, that is, S S E 4 *deg.* 4 *min.* Southerly.

2. *For the Ships true way, or compound motion.*

As the Sine of the Deflection	*D A B* 18 *deg.* 26 *min.*		9.5000
To the Current	*D B* 2 miles		0.3011
So *Radius*			
To the true motion	*A D* $6\frac{32}{100}$		0.8011

So the Ships compound motion is $6\frac{32}{100}$ miles hourly, that is, $6\frac{1}{3}$ miles almost.

5. *A Ship sails West 5 days together by the* Log, *725 miles, but there is a Current, all this while setting to the Southwards 1 $\frac{1}{2}$ miles an hour: I demand how far she hath sailed, and how far?*

The Current setting 1 $\frac{1}{2}$ miles an hour, sets in 5 days 180 miles:

Therefore, As

As the ſimple motion	*A B* 725 miles	7.1397
Is to the Current	*D B* 180 miles	2.2553
So is *Radius*		
To the Tangent of Deflection	*t D A B* 13 *d.* 57 *m.*	9.3950

For the Diſtance.

As ſine compl. the Deflection	*sc D A B* 13 *d.* 57 *m.*	0.0130
Is to the ſimple motion	*A B* 725 m.	2.8603
So is *Radius*		
To the compound motion	*A D* 747 miles	2.8733

So the Ships true way is Weſt Southerly 13 *deg.* 57 *min.* or Southweſterly 76 *deg.* 3 *min.* 747 miles.

6. *A Ship ſails Weſt* 5 *days together by the* Log 725 *miles, in a Current ſetting to the Southwards, and then finds that he hath altered his Latitude* 3 degrees; *I demand the motion of the Current, the* Rumb, *and true way of the Ship?*

This Queſtion differeth little from the former, for ſeeing the difference of Latitudes is 3 *deg.* the motion of the Current is 180 miles: ſo there is given the Ships ſimple motion, and the motion of the Current, as before, *&c.*

7. *A Ship in* 6 *hours ſails from a certain* Cape *or Head-land South* 30 *miles by the* Log, *in a Current ſetting Eaſterly, and then obſerving the ſame* Cape, *he finds that it bears* N N W; *I demand how faſt that Current ſets, and how far he hath ſailed?*

As let a Ship ſail from *A* towards *B* South 30 miles, but by means of the Current, ſhe is driven more Eaſterly, namely to *D*, from whence ſetting the Cape *A*, it is found to bear *N N W.* And ſeeing the Current ſets from *B* towards *D* Eaſterly, therefore the angle of Reflection *B D A* is 6 Points, that is, 67 *deg.* 30 *min.* Here then is demanded the diſtance *A D*, and the drift of the Current in that time *B D.*

As the ſine of the angle of Reflection	*s B D A* 67 *d.* 30 *m.*	.0344
To the ſimple motion of the Ship	*A B* 30 miles	1.4771
So the ſine of the angle of Deflection	*s D A B* 22 *d.* 30 *m.*	9.5736
To the motion of the Current	*B D* 12 $\frac{24}{100}$	1.0851

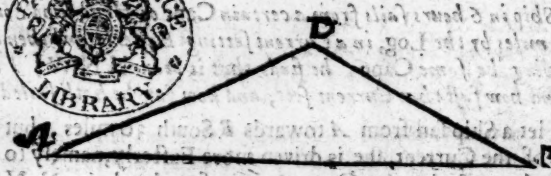
And further,

As the sine of the angle of Reflection 58 *D B A* 67 *d.* 30 *m.* 0344
To the distance run by the Log *A B* 30 miles, 1.4771
So is *Radius*
To the compound motion of the Ship *A D*, 32 $\frac{47}{100}$ 1.5115

And thus we find that Current to set 12 $\frac{16}{100}$, that is, near 12 $\frac{1}{6}$ miles in 6 hours, and the distance run to be 32 $\frac{1}{2}$ miles almost.

That the thing may be better conceived, we will use two or three Examples more familiar and obvious to every mans experience; yet grounded upon the same Principles and Reasons.

3. *Admit that* Tulis-stairs *bear from* Billingsgate-stairs *South-west Southerly, namely, Southwesterly* 40 degrees, *and be distant* 80 *Poles: and suppose the Tide Ebb off to run there Eastward* 2 $\frac{1}{2}$ *Miles an hour, and that a pair of Oars, rowing* 4 $\frac{1}{2}$ *Miles an hour, would go straight over from the first to the second: How shall they row over, namely, upon what* degree *or Point of the Compass, and how far shall they row to get thither, and in what time?*



Let *A* represent *Billingsgate-stairs*, *D Tulis-stairs*, *A E* the simple motion of the Boat, *E D* the motion of the Current, then is *A* the angle of Deflection, *E* the angle of Incidence, *D* the angle of Reflection 130 *deg.* 50 *min.*

As the simple motion of the Boat *A E* 4 $\frac{1}{2}$ miles 9.34679
Is to the motion of the Tide *D E* 2 $\frac{1}{2}$ miles 0.39794
So the Sine of Reflection *D* 50 *deg.* 9.38425
To the Sine of Deflection *A* 23 *d.* 3 *m.* 9.62898

Thus then the Position, from *A* to *D*, being Southwesterly 40 *deg.*

deg. and the angle of Deflection *A* 23 *deg.* 3 *m.* the position from *A* towards *E*, is Southwesterly 63 *deg.* 3 *min.* that is, *WSW* Southerly. And so must those Oars row to go straight over.

Secondly, for the distance A E.

From the angle of Reflection	*D*	50 *deg.* 00 *min.*
Substract the angle of Deflection	*A*	23 *deg.* 03 *min.*
And there rests the angle of Incidence	*E*	26 *deg.* 57 *m.*

As the fine of Incidence	*s E* 26 *d.* 57 *m.*	9.34370
Is to the true distance	*A D* 80 Poles	1.90309
So the Sine of Reflection	*s D* 50 *deg.* 00 *min.*	9.88425
To the simple motion	*A E* 135 $\frac{3}{10}$ Poles	2.13104

Lastly, for the time, seeing 320 Poles make a Mile, and they row, 4$\frac{1}{2}$ Miles an hour, it is 1440 Poles in an hour: so the proportion is,

As the simple hourly motion	1440.	6.8416
To the simple motion before found	135 $\frac{3}{10}$	2.1310
So is an hour in Minutes, namely	60 *min.*	1.7781
To the time required in Minutes	5 $\frac{61}{100}$	0.7507

And so long will they be Rowing over.

9. *But suppose they will row harder, to go a shorter cut; namely, to go Southwest by West: How fast must they go to row straight over, and how far, and in what time?*

Then seeing the Proposition from *A* to *D* is Southwesterly 40 *deg.* and Southwest by West is Southwesterly 56 *deg.* 15 *min.* therefore the angle of Deflection at *A*, is 16 *deg.* 15 *min.* the angle of Reflection *D* as before, 50 *deg.* 0. *min.* the angle of Incidence *E* is 33 *deg.* 45 *min.*

As the Sine of Deflection	*s A* 16 *deg.* 15 *min.*	55311
To the motion of the Tide	*D E* 2$\frac{1}{2}$ miles	0.39794
So the Sine of the angle of Reflection	*D* 50 *deg.* 0 *m.*	9.88425
To the simple hourly motion of the Boat	*A E* 6 $\frac{210}{1000}$	0.83530

And such is the hourly motion of the Boat, namely, 6 $\frac{210}{1000}$ miles in an hour.

Secondly,

Secondly, for the simple motion.

As the Sine of Incidence	*s E* 33 *deg.* 45 *m.*	0.25526
Is to the true distance	*A D* 80 Poles	1.90309
So the Sine of Reflection	*D* 50 *deg.* 0 *min.*	9.88425
To the simple motion	*A E* 110 $\frac{1}{10}$ Poles	2.04260

Thus it appears they must Row 110 $\frac{1}{10}$ Poles to get over.

Lastly, for the time.

The hourly motion before found 6 $\frac{444}{1000}$ reduced into Poles, is		2190 $\frac{1}{10}$
As the simple hourly motion	2190	6.65956
Is in proportion to an hour, or	60 *min.*	1.77815
So is the simple motion before found	110 $\frac{1}{10}$	2.04260
To the time required	3 $\frac{222}{1000}$ *min.*	0.48031

And so long will they be Rowing over.

10. *But admit a Sculler Rowing* 3 *miles an hour, would cross straight over at the same time, upon what Point must he row, and how far to get thither, and in what time will he do it?*

First, *For the Angle of Position.*

As the hourly motion of the Boat	*A E* 3 miles	9.52288
To the Sine of Reflection	*D s* 50 *deg.*	9.88425
So is the hourly motion of the stream	*D E* 2 $\frac{1}{2}$ *min.*	0.39794
To the Sine of Deflection	*A s* 39 *deg.* 40. *min.*	9.80507

Now seeing the position for *Billingsgate* to *Tulls-stairs*, namely from *A* to *D*, is by supposition to the Westwards of the South 40 *deg.* and the angle of Deflection *A* is here found to be 39 *deg.* 40 *m.* therefore the position from *A* to *E* is from the South to the Westwards 79 *deg.* 40 *min.* which is *W* and by *S*, and almost 1 *deg.* Westerly, and so must that *Sculler* row to go straight over.

Secondly, *For the distance A E.*

From the angle of Reflection	*D*	50 *deg.* 00 *min.*
Substracting the angle of Deflection	*A*	39 *deg.* 40 *min.*
There rests the angle of Incidence	*E*	10 *deg.* 20 *min.*
As the Sine of Incidence	*s E* 10 *deg.* 20 *min.*	.74624
To the true Distance	*A D* 80 Poles	1.90309
So is the Sine of Reflection	*s D* 50 *deg.* 0 *m.*	9.88425
To the simple motion	*A E* 341 $\frac{6}{10}$ p.	2.53358

And

And thus it appears, that though the distance of the two places be but 80 Poles, yet if according to the Question, he row but after 3 miles an hour, and the stream set after 2 $\frac{1}{2}$ miles an hour, then he must row 341 $\frac{6}{10}$ Poles to go straight over.

Lastly, *For the time.*

Three Miles is 960 Poles, say then

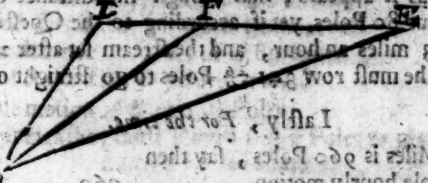
As the simple hourly motion	960	7.01773
To the simple motion before found	341 $\frac{6}{10}$	2.53358
So is an hour in minutes, namely	60 *min.*	1.77815
To the time required in minutes	21 $\frac{1}{100}$	1.32946

And thus it appears, that the time requisite to row over, rowing 3 miles an hour, is 21 $\frac{1}{100}$ minutes, whereas we found before, that rowing there 4 $\frac{1}{2}$ miles an hour, they might row over in 5 $\frac{6}{100}$ minutes, which is little more than a fourth part of the time.

There might be other, and that great variety of Questions of this nature propoled and resolved, many of good use in practice, which the Water-men by daily experience without other Rules, are able to guess at something nearly, sufficing for their occasions: My intent in these is especially to explicate the compound motion of a Ship, or other Vessel, Sailing or Rowing where there is a Current, which by such familiar Examples may seem more evident. I cannot insist upon them by reason of my other occasions, nor spend that time in these here handled, which else I should have done; whence if any defect or mistake should arise, if the Reader be pleased to give me friendly notice of it, I shall as thankfully accept it, and reform it. We propose next a Question at Sea, which let be this:

11. *There is a Current at Sea setting East 12 miles in 24 hours, a Ship sails in the same from a certain Port West South-west 6 days, and then returning thence, and sailing N. E and by North 3 days, falls with the Port from whence he first departed, I demand what his dead reckoning was outwards, and what back again, and how far these two Ports were asunder, and upon what Point of the Compass?*

As



As let the Current set from *E* towards *D*, and let the first Port be *A*, the second *F*, and let the Course outward bound be represented by *A E*, and the Course homewards by *D A*, &c.

And forasmuch as *D E* is an East and West line, and *A E* West Southwest, therefore the Angle at *E* is 22 *deg.* 30 *min.* and by the like reason, the Angle at *D* is 123 *deg.* 45 *min.* or 56 *deg.* 15 *min.* and the Angle at *A* 33 *deg.* 45 *min.* and *E D* being the setting of the Current for 9 dayes, is 198 Miles.

First then, for the dead reckoning outwards, namely, A E.

As the Sine of the Angle at *A* is 33 *deg.* 45 *min.*		.25526
To the Line *D E*	198 Miles.	2.03342
So is the Sine of the Angle at *D* 56 *deg.* 15 *min.*		9.91985
To the Line *A E*	163/4	2.20853

Thus *A E* his dead Reckoning outwards is 161/2.

Secondly, for A D.

As the Sine of the Angle *D A E* is	33 *deg.* 45 *min.*	.25526
Is to the Line *D E*	198 Miles	2.03342
So is the Sine of the Angle *D E A* is	22 *deg.* 30 *min.*	9.58284
To the Line *A D*	74 1/20 Miles	1.87152

Which 74 1/20 Miles is his dead Reckoning homewards.

Thirdly, for the Angle D A F *or* D F A.

The side *A* found	74 1/20 Miles
The side *D F* for three dayes, is	36 Miles
The sum of both is	110 1/20
Their Difference is	38 1/20
The sum of the Angles *D A F* and *D F A*	56 *deg.* 15 *min.*
The half sum is	28 *deg.* 7 1/2 *min.*

The

The Proportion.

As the sum of the sides	110 $\frac{2}{10}$	7.95703
Is to their difference	38 $\frac{8}{10}$	1.58433
So is the Tangent of	28 *deg.* 97 $\frac{1}{2}$	9.72706
To the Tangent of	10 *deg.* 32 *m.*	9.26932

Which added together, make the Angle *D F A* 38 *deg.* 39 $\frac{1}{2}$.

And seeing the Rumb from *F* to *D* is East, and the angle *D F A* 38 *d.* 39 *m.* $\frac{1}{2}$, therefore the Rumb from *F* to *A* is to the Northwards of the East 38 *deg.* 39 *m.* $\frac{1}{2}$, that is *N E* by *E* almost half a Point Notherly, which is the *rumb* from the second Port to the first. *Lastly, for* A F *the distance of these two Ports.*

As the Sine of the Angle	*D F A*, 38 *deg.* 39 $\frac{1}{2}$	.20434
To the dead Reckoning Homewards	*A D* 74 $\frac{2}{10}$ Miles	1.87151
So is the Sine of the Angle	*D* 56 *deg.* 15 *min.*	9.91985
To the Distance	*A F* 99 $\frac{2}{100}$ Miles	1.99571

Thus the true distance of those two Ports is 99 Miles, and somewhat more.

Sundry other Questions of like nature might be proposed, which to him that well understandeth, these will not be difficult.

These Principles a little inlarged, may further with a few Experiments be applyed in the discovery of some Mysteries in compound motions not yet divulged; though much endeavoured by sundry Famous Men in several parts of *Europe*, but these we shall not touch at prsent.

12. *To find where there is a Current at Sea, also which way it sets, and how fast.*

THis may be done by comparing the Reckoning outwards with the Reckoning homewards, whereof we will give an Example or two.

First, admit a Ship Sail from a certain Port, by one or several (Rumbs or Distances,) till she arrive at a second, and there find Reckoning by Course and Distance, that she is more Southerly than the Port from which she departed by 541 Miles, and more Westerly by 145 Miles: But by his Reckoning homewards,

wards, when he arrives again at the first place, he finds himself to the Northwards of the second 541 Miles, as before, and to the Eastwards 305 Miles. Now supposing he were 5 dayes outwards bound, and 5 dayes homewards bound, I would know which way the Current sets, and how fast? Here, because the Easterly distance homewards is greater than the Westerly distance outwards, therefore from the Easterly distance 305 Miles, substract the Westerly distance 145 Miles, the remainder being 160 Miles, is the motion of the Current to the Westwards.

And thus it appears, that the Current sets to the Westwards, 160 Miles in eight dayes, that is, 20 Miles a day, or $\frac{1}{6}$ of a Mile every hour.

2. *Example.* Admit a Ship Sail from the *Summers-Island*, by several Rumbs and Distances, till she arrive at Cape *Codd* in *New-England*, namely, from the East part of *Summer Islands* (the Variation being allowed) first, North 20 Miles, and then *NNW* 150 Miles, the second day *N* by *W* 180 Miles: The

	North.	South.	East.	West.
North 20 Miles	20 0			
North North West 150 Miles	138 6			57. 4
North by West 180 Miles	136 5			35. 1
North 90 Miles.	90 0			
Northeast 88 Miles	62 2		62 2	
528 Miles	487 3		62 2	92. 5
				62. 2
				30. 3

third day North 90 Miles; the fourth day Northeast 88 Miles, and so arrive at Cape *Codd*: Then by these Courses and distances we may gather by the foregoing Table, that Cape *Codd* should by this Reckoning be to the Northwards 487 Miles: And to the Westwards 30 Miles, as here appears.

Now suppose she Sail back again from Cape *Codd* towards the *Summer-Islands*, the first day *SSW* 150 Miles, the 2 day *SSW* 160 Miles, the third day *S* by *W* 130 Miles, the fourth day South 140 Miles, the fifth day East 110 Miles, and so be come again to the East part of the *Summers-Islands*. South

	North.	*South.*	*East.*	*West.*
South S W 150 Miles		138. 6		57. 4
South S. W. 160 Miles		147. 8		61. 3
South by W. 130 Miles		127. 2		25. 3
South 140 Miles		140. 0		
East 110 Miles			110. 0	
690 Miles		554. 0	110. 0	144. 0
				110. 0
				34. 0

These Courses and Distances make, as here appeareth, the *Summer-Islands* to be to the Southwards of Cape *Codd* 34 miles, and to the Westwards 110 miles.

Therefore by this last Reckoning back again, Cape *Codd* should be to the Northwards of the *Summer-Islands* 554 miles, and to the Eastwards 34 miles, whereas by the former Reckonings outwards it was to the Northwards only 487 miles, and to the Westwards 30 Miles. So that the difference of these two Reckonings outwards and back again, is 67 miles Northerly, and 64 miles Easterly, which sheweth that the Corrent in that time, namely in Nine days, hath set to the Northwards 67 miles, and to the Eastwards 64 miles, that is, Northeast little Northerly, 93 miles, as by the fore-going Table doth appear, which is 10½ miles every day.

And what we have here done by the Tables might have been done (as the foregoing Problems) by the *Doctrine of Plaine Triangles*

FINIS.

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